Competing in a Decentralized and Sustainable World: Future Organizations in the Hazardous Waste Remediation Industry

by

Michael J. Garvin, II

B.S., Civil Engineering
United States Military Academy, 1989

Submitted to the Department of
Civil and Environmental Engineering in Partial Fulfillment of
the Requirements for the Degree of

MASTER OF SCIENCE
in Civil and Environmental Engineering
at the

MASSACHUSETTS INSTITUTE OF TECHNOLOGY

February 1995

Signature of Author .....
Department of Civil and Environmental Engineering
January 13, 1995

Certified by .....
Professor Fred Moavenzadeh
Director, Henry L. Pierce Laboratory
Department of Civil and Environmental Engineering
Thesis Supervisor

Accepted by .....
Joseph M. Sussman
Chairman, Departmental Committee on Graduate Studies

Competing in a Decentralized and Sustainable World:
Future Organizations in the Hazardous Waste Remediation Industry

by

Michael J. Garvin, II

Submitted to the Department of Civil and Environmental Engineering
on January 13, 1995 in partial fulfillment of the requirements
for the Degree of Master of Science in
Civil and Environmental Engineering

ABSTRACT

Recent movements in business and ecological management contradict the existing paradigms developed during this century. Longstanding assumptions about organization and coordination as well as natural resource use and conservation are under scrutiny. Decentralization challenges the traditional notions of hierarchical organization and vertical coordination by emphasizing lateral coordination and autonomous decision-making. Vertically integrated organizations where all activities occur from within are dwindling, and horizontal organizations where core competencies are complemented through partnerships and subcontracting are flourishing. Further, the concept of permanent organizational employment is suspect as advances in information technologies and networks make remote interaction more possible. Perhaps, work in the future will center upon temporary project arrangements between groups or individuals. Sustainable development, the new ecological paradigm, looks to balance natural resource exploitation and protection by encouraging economic and ecological harmony. Yet, sustainable development's significance stretches beyond its potential for efficient management; it is a mandate for future investment and a responsible legacy.

The form of organizations in the next century is dependent upon the burgeoning trends of decentralization and sustainability. This thesis examines these trends to discover their implications upon future organizations in the hazardous waste remediation industry. This discussion is complemented by a thorough analysis of remediation markets, approaches to risk management, and technological development in a maturing industry. Finally, the thesis presents an alternative for a future organization as it describes the qualities and offers a generic model of an organization providing remediation services in the 21st century.

Thesis Supervisor: Dr. Fred Moavenzadeh

Title: Director, Henry L. Pierce Laboratory
Department of Civil and Environmental Engineering

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

ACKNOWLEDGMENTS

On rare occasions do we get to formally thank those who have made a difference in our lives. The credit for my accomplishments rests with these people:

- My mother and father; through the years, they have stuck by me with constant support and love.
- Bettye; during the past year, when I needed encouragement, a smile, or just a hug, she provided these and more.
- Dr. Fred Moavenzadeh; his assistance has been invaluable during my stay at MIT.
- Charlie Helliwell, Pat Vargas, and Danielle Severino; their support made my MIT experience plausible and enjoyable.
- Bob, Dan, David F., Andy, Brant, and David W.; their ideas, insight, and friendship were the best part of MIT.
- Jarome, Tom, Jeff, and John; they have always been around when I needed a friend.

AUTHOR

Michael Garvin is a 1989 graduate of the United States Military Academy. During his service as an officer in the Corps of Engineers, he held positions as a platoon leader, executive officer, support platoon leader, and assistant brigade engineer. The highlight of his service was a seven month deployment to Saudi Arabia and subsequent participation in Operations Desert Shield and Storm. He left the service in the summer of 1993 to attend MIT where his interests are ecological issues in construction and construction organization and management.

PREFACE

When I entered the United States Military Academy as an ambitious seventeen year old in the summer of 1985, I was ecstatic about the opportunity before me. West Point promised intellectual, emotional, and physical challenge, a wonderful environment for growth. Beyond the possibilities for personal development, I was also excited about becoming a part of something greater than myself, not simply the tradition and legacy of West Point, but its purpose--to produce graduates of character, inspired for a lifetime of service to the nation. Throughout my experience at the Academy, I tried to never lose sight of this, although at times it was quite difficult. Upon graduation and commission, I was proud to have become a small part of West Point's heritage. The Academy had balanced well my personal development with its purpose. I, indeed, felt part of something greater than myself.

In the summer of 1993, I left the US Army. Somehow, I had lost sight of my original intentions. I recall a discussion with my senior commander where I told him that I was disappointed that the Army had failed to meet my needs. While I still felt pride that I was serving my nation, I had become frustrated with the lack of autonomy and creative challenge present in my assignments. In short, ***I*** was just unhappy. For some reason, just being a part of something greater than myself was not enough. From my perspective, the Army seemed to lack the balance between individual and whole. The whole dominated the individual, stagnating personal development. Since arriving at MIT, I have become intrigued by developing theories of organizational design, particularly trends toward decentralization. Its supporters argue that distributing authority and power to peripheral elements of an organization increases the organization's ability to adapt to its environment. Obviously, it also provides individuals greater autonomy. Aside from this, many organizational theorists are discussing methods for heightening workforce fulfillment. How can an organization structure itself and operate to assist workers in their professional and personal development? Further, how can it balance the individual against the whole in an effective union? Reflecting upon my own experiences, these thoughts easily grabbed my attention; they provide the motivation for this thesis. I intend to challenge traditional thoughts and concepts of economic and organizational theory. My hope is to act as a prophet rather than a dreamer. While I certainly might introduce revolutionary ideas, I intend to ground them in reality. The result, I hope, is a real roadmap for organizational change into the next century.

Chapter 1
INTRODUCTION

The world we have created today . . . has problems which cannot be solved by thinking the way we thought when we created them.

- Albert Einstein

1.1 Brief Overview of the Remediation Industry

At its birth, the hazardous waste management industry was little more than a deviant of solid waste management. Hazardous waste handling, transport, and disposal were the primary activities in the industry, and not surprisingly, solid waste firms were the first to diversify. In the 1980s, the face of the industry changed with the passage of the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA or Superfund) and the Hazardous and Solid Waste Amendments (HSWA) to the Resource Conservation and Recovery Act (RCRA). In 1980, CERCLA was enacted to regulate the cleanup of the growing number of abandoned, contaminated sites. The most significant aspect of CERCLA was its determination of legal liability. Liability for abandoned hazardous wastes rested with parties who "caused or contributed to release of hazardous wastes", which later was ruled to include anyone who dealt with the waste in any manner what so ever. As time passed, the original funding for CERCLA proved far from adequate. In 1986, Congress passed the Superfund Amendments and Reauthorization Act (SARA) which added $8.5 billion to the fund. Additionally, its reauthorization hoped to speed the cleanup process which had crawled along since 1980 with only 14 sites fully cleaned. HSWA dramatically broadened the definition of hazardous wastes and those requiring monitoring. The number of substances regulated increased from 158 to over 400, and generators producing 220 lbs. per month rather than 2,200 lbs. now required monitoring. Additionally, the amendments directed waste generators to cleanup their existing contaminated sites, establishing guidelines for corrective action. Superfund and HSWA created a tremendous need for cleanup services.

Today, the hazardous waste management industry is quite different. The volume and complexity of hazardous waste cleanups created the remediation segment of the industry. Engineering and construction firms have entered this market only to discover a volatile environment. Regulatory trends are in a constant state of flux with a variety of standards enforced on local, state and national levels. Remediation technologies continue to evolve against multiple barriers to innovation. New competitors are commonplace as defense

contractors and others look to diversify. Finally, shifting ecological management paradigms heighten the uncertainty involved. As resource management and pollution prevention replace the existing protection ethos, the resulting effects upon government, the public, and private industry are unpredictable. Further, the burgeoning concept of sustainable development will only add to already erratic evolution of ecological management. Indeed, the remediation market is truly dynamic.

1.2 The Changing Ecological and Business Management Paradigms[1]

In recent years, we have seen a shift in our approaches to both ecological and business management. In the late 1960s and early 70s, the ecological movement forced both government and industry to reexamine their approaches. Since then, dramatic swings along our legislative, technological, resource, and economic fronts have occurred. Legislation and technologies once focused upon control of generated wastes have evolved to emphasize waste prevention and minimization. The 1970 Clean Air Act regulated incinerator discharge by testing smokestack emissions for compliance with ambient air standards while the Clean Water Act of 1972 regulated all industrial discharges into rivers, lakes, and oceans. Accordingly, filtration and purification technologies such as industrial scrubbers were predominant. Recently, the 1990 Pollution Prevention Act established a pollution prevention hierarchy as "national policy", and the Safe Drinking Water Act and the Clean Air Act Amendments of 1990 place greater emphasis upon preventing pollution rather than creating it. Now, source reduction and recycling technologies such as solvent recovery systems are common. Further, original product designs incorporate life cycle analysis techniques and allow greater reuse of materials. Before the birth of the ecological movement, the earth's resources were generally considered boundless. Today, insight from the *Environmental Business Journal* suggests that a significant result of the movement is the mass realization that our natural resources are finite. Finally, the economic manner of ecological management has changed from imposing financial penalties on violators to establishing fair market value for use of resources and fees for lessening their value by extraction or contamination.[2] Collectively, these changes point toward a sustainable approach for development.

---

[1]Normally, ecological management is referred to as environmental management. Since the word environment often has a different meaning than our natural, physical surroundings when used in a business context, throughout this thesis I use ecology rather than environment to avoid confusion.
[2]EBI. "Sustainable Development", Environmental Business Journal, July 1994, p. 1.

In business, the mass production paradigm resulting from the Industrial Revolution has begun to move toward a more flexible and responsive approach. Changes are evident in our methods of coordination, production, and employment. For the majority of this century, coordination was affected via vertical systems of organization. Today, lateral systems are increasingly utilized. Galbraith identifies several forces that are driving the need for lateral coordination:

diversity or variety: The greater the amount of diversity of products/services and market segments, the greater the need for lateral coordination across functions.

unanticipated changes: The greater the uncertainty and number of unanticipated changes, the greater the amount of information processing and decision-making required.

work interdependence: The greater the diversity of products, the more interdependent work units are, hence the greater the need for lateral communication.

total quality initiatives: Total quality (TQ) initiatives increase the interdependence of work units since TQ focuses all functions upon quality as defined by the customer.

time compression: More and more companies desire to reduce the cycles of production, order processing, financial transactions, etc. This increases the interdependence of units along the value-added chain.

The intensity of these forces within a business unit is making it increasingly difficult for hierarchical management structures to effectively coordinate activities. Hence, lateral coordination means have become more popular.

Beyond coordination, methods of production are less linear and more parallel or flexible. Dwindling are the days of assembly line manufacturing begun in the era of Ford early in this century. Today, flexible manufacturing systems and parallel development efforts reduce cycle times dramatically. Such systems provide rapid response, reduced waste, greater predictability, and faster throughput.[3] Finally, employment that was once singular and constant is becoming more variable and inconsistent. A recent article by William Bridges in *Fortune* magazine was alarmingly titled "The End of the Job", and its author forecasts that jobs are social artifacts that have outlived their usefulness as a way of organizing work. In the future, individuals will increasingly work from their homes and arrange their work on a temporary basis as projects come and go using sophisticated information systems and networks. Collectively, these changes point toward a decentralized business environment.

---

[3]Goldhar, J. and Jelinek, M. "Plan for Economies of Scope", Harvard Business Review, November-December 1983, p. 142.

The pairing of changing paradigms in ecological and business management might at first appear odd, but with some further investigation their mating is quite natural. I was struck recently by a chart from the *Environmental Business Journal* where it portrayed the evolution and penetration of the concept of sustainable development as a transition from linear to circular resource flows in our economy. Such a change requires greater integration, coordination, and communication by both upstream and downstream participants in the resource chain in a synchronous fashion. If participants rely upon vertical and linear approaches to coordination and production, the success of sustainable development is doubtful. All participants must understand the effects of their activities on others. Such a situation is analogous to coordination and production in business. In functional organizations, inputs from functional groups such as marketing to research and development to manufacturing are often "thrown over the wall", resulting in difficulties and delays in production. Decentralization looks to eliminate this linear form of operation through lateral coordination and grants of decision-making autonomy. Essentially, both sustainable development and decentralization require extensive lateral coordination for success. The world as we know it will likely change from a hierarchical and controlled one into a lateral and autonomous one.

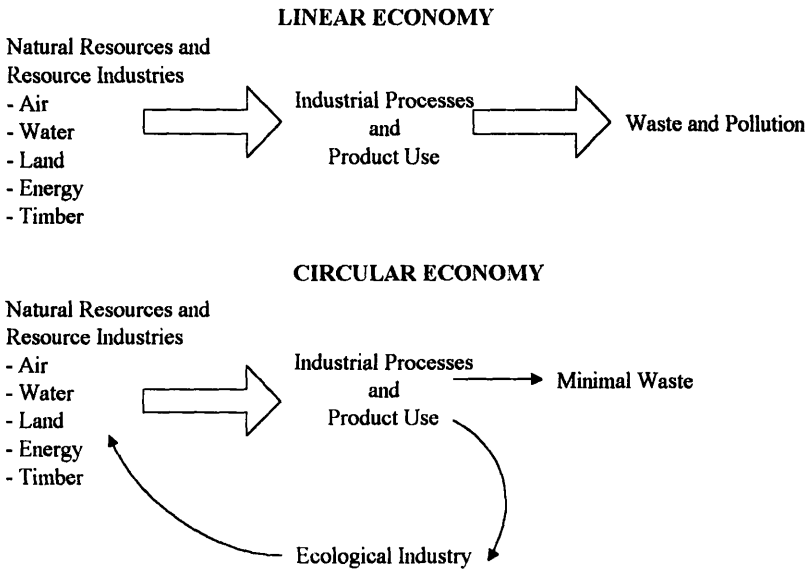

Figure 1. Resource Use Transition

1.3 Thesis Objectives and Organization

With the background just provided, I intend to further examine the general trends toward decentralization and sustainable development to discover their implications upon future organizations. Each paradigm is a fledgling concept, so I shall not attempt bold forecasts of their results. Rather, I hope to discover their pertinent message and build upon this discovery. In addition, I will look rather closely at market, liability, and

technological trends specific to the remediation industry and examine industry responses. From this analysis, I hope to understand the realities of the current situation, as well as their future implications, and suggest actions for improvement. From this trend analysis, I hope to provide the foresight necessary for the primary purpose of this thesis:

Describe the qualities and create a generic organizational model of a national remediation organization that might exist a decade into the 21st century.

I provide an alternative for organization in the next century.

Chapter 2 begins our study by looking more closely at what I describe as dominant--sustainable development and decentralization--and secondary--market, liability, and technological--trends. It provides the groundwork necessary for the creation of foresight that the following chapters will build upon.

Chapter 3 examines the remediation market. What services are provided and who participates? What are its segments? More importantly, what are the developing client tendencies for contracting methods, awards, and management? Each major client is examined in some detail and some general conclusions about the future of the market are drawn.

Chapter 4 examines the risk management approaches adopted by remediation firms as a result of the tenuous liabilities found in the industry. From this analysis, we discover that traditional approaches to risk management are quite adequate to mitigate the risks in remediation; however, greater involvement by contractors in risk communication and public relations efforts may become necessary in the future. Most contractors are unprepared or hesitant to assume this responsibility.

Chapter 5 concludes our analysis of the secondary trends presented in chapter two. Technological development in remediation is fraught with difficulty. Financial and regulatory barriers exist, and poor technology transfer mechanisms stifle innovation. I suggest an informal network of gatekeepers as a possible transfer mechanism.

Chapter 6 departs from our discussion of secondary trends and begins with a discussion of the underlying messages of sustainable development and decentralization. Once complete, the foresight necessary for creating our future organization is well in hand. Initially, I describe six qualities of a future organization followed by a presentation of alternative organizational forms. Finally, I create a generic organizational model of a future remediation organization by discussing the organization's purpose, structure, management, and culture.

Chapter 7 provides my final thoughts.

Chapter 2
TRENDS

Those who see. Those who see when they are shown. Those who do not see.
- Leonardo da Vinci

2.1 Foresight

Leonardo da Vinci did not utter those words in the context of modern strategy, yet they are extremely applicable. Organizations must structure and prepare themselves to adapt to changing environments. *Those who see*, organizations that recognize signals of pending events, acquire an advantage; *Those who see when they are shown*, organizations that react to developing events, probably survive; *Those who do not see*, organizations that fail to understand events or change because of them, are destroyed. Accordingly, this chapter is devoted to burgeoning and developing trends in the general business environment and, more specifically, in the realms of ecological management and hazardous waste remediation. These signals provide the landmarks for the organizational maps drawn by strategic planners. When these signals are understood and the organizational maps are drawn, many call the result the organization's vision. I prefer to use the term foresight, coined by Hamel and Prahalad in a 1994 *Harvard Business Review* article:

> *Vision connotes a dream or an apparition, and there is more to industry foresight than a blinding flash of insight. Industry foresight is based on deep insights into trends in technology, demographics, regulations, and lifestyles, which can be harnessed to rewrite industry rules and create competitive space.*

This chapter lays the groundwork for understanding the evolving business environment in remediation. Chapters that follow will complete this start and provide the foresight essential for developing a future organization.

2.2 The Dominant Trends

To develop foresight, I have classified the trends we shall discuss as either dominant or secondary. I characterize the dominant trends as more appropriate for establishing an organization's long-term plan, so they are particularly relevant to our definition of foresight. The secondary trends I have identified are more suitable for establishing a short-term plan, but the interplay between the trends makes them difficult to distinguish in such a fashion. I distinguish them this way to highlight their significance. An organization

that recognizes and prepares for the secondary trends but fails in this regard for the dominant trends will not survive in the long-term. I do not expect, however, that the converse of this is true, i.e. recognize long-term but not short-term means short-term failure. Instead, I foresee such an organization struggling today but thriving in the future.

Since hazardous waste remediation organizations provide services within a broader ecological services industry, I hope it is not surprising that I characterize two trends from approaches to business management and ecological management as dominant. Conducting business in the ecological services industry is somewhat unique since these firms must become particularly attuned to the topsy-turvy world of ecological management in addition to the usual economic and business environment. Currently, the burgeoning concept of sustainable development is attracting many ecological managers. Discussions of sustainable development abound, but generally it is defined as development that meets the needs of the present without compromising the ability of future generations to meet their own needs. In doing so, economic and ecological issues require equal and joint consideration. Today, the implications of such an approach to ecological management are just beginning to demonstrate themselves, and they are generally dictated by the shifting regulatory climate wherein this field lies. While some might argue that ecological regulations have invaded the decision-making processes of nearly all industries, none other than the ecological services industry rely upon them to create the need for their services. Again, others might argue that increasing ecological awareness in society has caused some firms to purchase ecological services voluntarily. True, but hardly any ecological service can be performed without regulatory influence. The future of ecological management is sustainable development, and this future is dictated by an evolving regulatory environment. Accordingly, the implications of sustainable development upon hazardous waste remediation are quite significant. We shall discuss this in greater detail later in this chapter and in chapter six.

Aside from shifting approaches to ecological management, any firm must recognize the significant swings in approaches to business management whether they prove viable or not. Otherwise, their competitors may latch onto a particular idea or technique that leaves them behind. Today, such a business management trend is developing, decentralization. Normal definitions of this trend describe it as the shift away from hierarchical organization toward horizontal organization. It has, what I call, internal and external edicts. Internally, authority, power, and function are distributed away from central control toward peripheral elements of the organization. In addition, coordination occurs laterally rather than vertically. The primary advantage of the internal organization is that it provides an organization the capability of adapting to its external environment; it is more flexible since

decision-making rests with fringe elements of the organization rather than in the hands of central authority figures. Another advantage often cited is organizational durability. Many decentralist theorists support a natural evolution of organizational principles and values that bond into a tight core. Violating the core principles becomes heresy, and altering them becomes arduous. Such an organization is nearly invincible to tyranny. The external edicts promote discovery of core competencies, continual development of them, and complementing them from outside the organization. Essentially, the organization chooses its specialty and then promotes and nurtures it. The organization will regularly partner or subcontract with other specialists to provide goods or services. With all this in mind, I define decentralization as flexible organization through competency discovery, development and complementation, lateral coordination, and autonomous decision-making.

2.2.1 Sustainable Development

For the majority of the twentieth century, society considered the ecology's capacity for absorbing all kinds of waste as generally boundless. Nature, given enough time, could dissipate human waste streams through its normal processes.[4] From an economic standpoint, the ecology at best was considered an insignificant externality. Not surprisingly, members of the government and private industry gave little thought to controlling the pollution created or preventing it in the first place. For example, hazardous wastes were usually sealed in 55-gallon drums and buried. Industrial chemicals and wastes were regularly flushed into the ocean, rivers and streams. Today, we might consider such activities as reckless, but under the prevailing notion that the ecology was an infinite sink such behavior was commonplace. In the past few decades, society has begun to realize the ecological results of its development activities. In the late 1960s and early 1970s, ecological advocates brought attention to the degradation created by existing industrial and consumer practices. In essence, the field of ecological management was born. The approach adopted emphasized ecological protection where controls were placed upon industry and consumers to handle the generated pollution. The US government created the Environmental Protection Agency (EPA) for the purpose of instituting nationwide ecological controls. In the late 1980s and early 1990s, the ecological management emphasis changed. Attention shifted from pollution control toward waste minimization and resource management. Regulatory programs like Title III of the 1986 Superfund

[4]Moavenzadeh, F. Global Construction and the Environment: Strategies and Opportunities, New York: John Wiley & Sons, 1994.

Amendments and Reauthorization Act had surprisingly significant effects on industry. The mere requirement that organizations make public their toxic release information awoke industry to the potential effects industrial practices might have on the ecology. The 1990 Pollution Prevention Act while only mandating limited requirements upon industry, did establish as "national policy" a pollution prevention hierarchy - source reduction, recycling, treatment and disposal. In addition, starting in 1992 organizations required to file toxic release information under SARA Title III had to also include information on the quantities of chemical wastes generated prior to recycling, treatment, and disposal. They must also submit information about current source reduction practices and efforts for identifying further source reduction opportunities. Efforts are underway to "ecologize the economy", attempts to affect the internalization of ecological considerations into business/economic decisions. Regulatory mechanisms are focusing upon economic incentives such as tradable permits, pollution charges and deposit-refund systems such as the nation's tradable permit program for sulfur dioxide emissions under amendments to the Clean Air Act of 1990. Indeed, ecological management has evolved substantially since its creation.

Sustainable development advances ecological management into another dimension. Michael Colby describes this concept:

> *[Sustainable development] more explicitly sets out to restructure the relationship between society and nature into a 'positive sum game' by reorganizing human activities so as to be synergetic with ecosystem processes and services, as opposed to the back-to-nature 'simple symbiosis' advocated by deep ecologists.*

Essentially, our economy and ecology become harmonious. Economic prosperity depends upon our world's resources. Instead of exploiting or harboring them, sustainable development hopes to capitalize upon them while maintaining their availability for the future. Colby further describes the concept as *ecocentrism*: refusing to place humanity either above nature or below it. This concept has spawned such ideas as constructed wetlands where wastewater is treated in a natural setting by natural processes.

Beyond the regulatory trends that portend this not-to-distant future in ecological management, a host of other efforts indicate its emergence. On June 14, 1992, the United Nations Conference on Environment and Development created Agenda 21, a comprehensive program for governments, development agencies, UN organizations, and independent groups in any area where human activity affects the ecology. Its underlying theme is the creation of governances in economic policies that bring about a more prosperous future for us all. Its preamble calls such an approach "a global partnership for

sustainable development".[5] The July 1994 edition of the *Environmental Business Journal* describes business initiatives that encourage sustainable development. Sustainability, Ltd., an ecological consulting firm in the U.K., pushes "its business partners [clients] toward sustainable development". EcoRating International, Inc., a multidisciplinary consulting firm based in Zurich, Switzerland, measures ecological performance in relation to a how well a product, process or firm contributes a Net Environmental Gain (NEG). Generally, NEG is defined by sustainability and best available technology. Additionally, lending institutions such as the World Bank are slowly instituting ecological considerations and reform into their lending practices.

Finally, efforts lead by groups such as the Coalition for Environmentally Responsible Economies (CERES) and the Chemical Manufacturing Association (CMA) are gaining prominence. The CERES Principles provide a model corporate code of ecological conduct, and an organization which endorses them pledges to monitor and improve its behavior in several critical areas including its sustainable use of natural resources and its products and services. Most notably, the organization must substantiate its pledge by reporting annually information regarding each of the critical areas in the CERES report, which is available to the public. By adopting the principles, CERES claims that organizations will benefit through improved ecological performance, recognized leadership, positive media attention, and improved employee relations. Recently, the first Fortune 500 company, the Sun Company, adopted the principles. The CMA's Responsible Care program began in the U.S. in 1988, following Canada's lead. The chemical industry hopes to reverse its worsening image by a combination of continuously improved ecological performance and establishing a new responsiveness to public concerns.[6] Arguably, the self-imposed standards developed by the chemical industry are ahead of any similar initiatives in other industries. These standards represent a valuable effort toward corporate ecological responsibility regardless of their motivation.

Clearly, the concept of sustainable development has many allies. Regulatory mechanisms are emphasizing the balance of ecological and economic activities. Global initiatives such as UN Agenda 21 encourage sustainable economic activity. Ecological consulting firms encourage and evaluate sustainable efforts of their clients while lending institutions are beginning to consider ecological issues in their financing decisions. Further, independent and industry-lead groups are promoting ecological awareness in

---

[5]Muhlhauser, C. and Lukacs, J. "Sustainable Development: Foundation of Future Environmental Solutions", ENR, Special section on environmental engineering, November 22, 1993, p. E-20.
[6]"Responsible Care", Chemical Week, July 7-14, 1993, p. 16.

business and economic activities. Sustainable development may not be the future; it may be the present.

2.2.2 Decentralization

In the late 18th and early 19th century, a dramatic change occurred in the world economy. Wage laborers replaced artisans, and mass produced goods replaced handcrafted items. The organizations of this century were guided by the principles of division of labor, economies of scale, and hierarchical control under Adam Smith's industrial paradigm. Today, we are in the midst of a new revolution. Malone and Rockart comment:

> *Changes in the economies of production and transportation drove the revolution of the last century. The revolution underway today will be driven not by changes in production but changes in coordination.*

Malone, the director of MIT's Center for Coordination Sciences, and Rockart, director of MIT's Center for Information Systems Research, suggest that the true "driver" of decentralization is a new paradigm of coordination. Whenever people work together for a common purpose, they communicate, make decisions, allocate resources, and transfer their results to some place at some time. Almost everyone in business performs coordination activities.[7] In the past, coordination was handled through vertical mechanisms such as managerial supervision or standards of practice. Today, Malone and Rockart suggest that information technologies are dramatically reducing the costs of coordination and increasing its speed and quality, and the effects of these systems will change our methods of organization and management.

Malone and Rockart are not alone in their assertions. A recent article from *Fortune* magazine suggests several trends that will reshape the workplace. First, traditional hierarchical organizations will give way to a variety of organizational forms, foremost of which is the network of specialists. The future organization may become an outfit pared down to its core competencies and sending out for all else.[8] Second, a horizontal division of labor will replace the vertical division. Stephen R. Barley, professor at Cornell's School of Industrial and Labor Relations, comments that "vertical divisions of labor encode expertise in rules, procedures, and positions", so learning occurs primarily about the organization itself. A horizontal division "rests upon the assumption that knowledge and

---

[7]Malone, T. and Rockart, J. "Computers, Networks, and the Corporation", Scientific American, September 1991, p. 2.
[8]Keichel, W. "How We Will Work in the Year 2000", Fortune, May 17, 1993, p. 41.

skills are domain-specific and too complex to nest within a hierarchy." The new worker becomes a specialist with dual loyalties to both her organization and specialty. Specialists fit the described core organizational model quite well, and perhaps explain the trend toward multifunctional teams. Finally, work itself will require constant learning, higher-order thinking, and less "normal" work hours. The new era will bring remote interaction, possibly from home. Leaving problems for tomorrow will become more difficult. "Individual contractors" will scramble to complete projects and arrange their next one. Indeed, the business world of tomorrow may only remotely resemble that of today.

Other theorists further describe the trend. Perhaps most prominent is the recent work by Peters entitled *Liberation Management: Necessary Disorganization for the Nanosecond Nineties*. In this work, he describes advances in information systems, organizational restructurings, trends toward networks and subcontracting, and the burgeoning of a knowledge-based society. Essentially, he suggests a need for a revolution in management, organization, and thought. Control is out; liberation is in. Kelly examines multiple natural systems as models for society and organization in his work on the rise of a neo-biological civilization. He describes bee hives and swarms, ant communities, and coral reef replicas. From his analysis, he develops nine laws of god that include control from the bottom up and maximizing the fringes. Finally, Hammer & Champy's *Reengineering the Corporation: A Manifesto for Business Revolution* has become nearly "required reading" for business people.

How can so many make such assertions about the coming millennia? All indicate that the computer and its networks allow such changes. Today, a variety of information systems facilitate different forms of interaction. Electronic meeting systems support group work by generally using computers, software applications, and a shared large screen monitor to assist in meetings or discussions. Supporters argue these systems can impact and change the behavior of groups to improve effectiveness, efficiency, and satisfaction by focusing efforts, eliminating hidden agendas, and encouraging those hesitant to participate.[9] Increasingly common are e-mail systems that allow informal or formal communication between groups or individuals from remote locations at different times. Lotus Notes, a product of Lotus Development Corp., is a rather sophisticated system of this sort. Its most commonly used feature allows remote stations to "replicate" databases from a server onto their local computer, alter the database, and "return" it to the server for others to view, edit, etc. More powerful are developing synchronous systems that allow remote interaction at the same time. Bell Labs' Rapport system lets co-workers jointly

[9]Nunamaker, J., Dennis, A., Valacich, J., Vogel, D., and George, J. "Electronic Meeting Systems to Support Group Work", Communications of the ACM, July 1991, p. 41.

	Same Place	Different Place
Same Time	**Electronic Meeting Systems**	**Bell Labs' Rapport** **NTT's TeamWorkStation**
Different Time	**E-mail Systems**	**E-mail Systems** **Lotus Notes**

Table 1. Groupware

edit computer files as they discuss them either through voice and data only or through full motion video. NTT's TeamWorkStation allows users to transfer work from their individual screens onto a shared workspace for collaboration. Cameras mounted on peripheral devices send images of the user's face and desktop to the shared screen. Xerox's VideoDraw lets a designer sketch on a monitor with an erasable marker while an overhead camera sends the image to another's monitor. Together the designers can alter and shape schematic images. These systems continue to mature; over time, their influence upon coordination and interaction will prove dramatic.

Organizations have followed suit by changing their structures and methods of coordination. Visa International instituted many of these concepts long before they were fashionable under the leadership of Dee Hock. Hock and company created an organization following four general principles:

- The organization must be equitably owned by all participants.
- Power and function must be distributed to the maximum degree.
- Authority must be distributive within each governing entity.
- The organization must be infinitely malleable but extremely durable.

Beyond these principles, Visa held as its core value trust and cooperation amongst its employees. Few can argue with the success Visa has achieved.[10] Xerox jumped on the band wagon during the early 1990s when they re-examined their corporate strategy and organization to prepare for the future. According to John Seely Brown, Vice President and Chief Scientist, Xerox chose to organize for speed and manage for synergy rather than to organize for synergy and manage for speed to meet the growing needs of their document customers. The result of their plan was a leaner organization where several autonomous business units were created and supported by a corporate staff and a research and development group. While many might argue the soundness of their decisions, Xerox's reorganization demonstrates their perception of the need to improve flexibility.[11]

[10]Hock, D. Lecture delivered at MIT on September 28, 1994.
[11]Seely Brown, J. Lecture delivered at MIT via video conference on September 21, 1994.

Countless others, including monsters such as IBM and General Electric, have restructured themselves to meet the changing needs of today's consumers.

Beyond the support of theorists, the developing information technologies, and the organizational examples are four additional "drivers" of decentralization. I present these as a result of my own readings on the subject, and I expect their interaction will continue to force decentralization in the future:

Complexity - Our world is increasingly complex. Products are now assemblages of components produced throughout the nation or the world. Pollution migrates across property, local and international borders. Nations are heterogeneous unions of various cultures and languages. Designs incorporate life-cycle analysis that include ecological, material, and energy considerations. Business is conducted electronically on a global scale. Governments lead an increasingly aware populace that organizes, protests, and substantially influences its decisions. From my own managerial experience, I learned that as the environment became more complex, I had to relinquish some control. Similarly, control just does not work anymore.

Consumption - Our society is in the age of the consumer. Here, I am not arguing that we are obsessed with excess (although I might agree that this is true), but rather that the power base in our economy has shifted from the producer to the consumer. No longer can industries spin out generic products and expect consumers to buy them (except for maybe toothpaste and the like). We are in an age where the consumer can demand custom colors and features on products and expect almost immediate gratification, even on products like automobiles where only a short time ago this seemed unfathomable. Hierarchical organizations have proved incapable of meeting such demands, thus the reorganization examples cited previously.

Frustration - Jobs are scarce, violence is rampant, prices are high, pollution is everywhere, crime is uncontrolled, work is monotonous. Whether these societal perceptions indicate real issues for concern or hysterical ones created by media exposure is somewhat irrelevant. The fact remains that US citizens are concerned about these issues. Still skeptical, look at any political campaign from the past election season. These were the issues being addressed, and more than anyone, politicians cater to the public's concerns. More importantly, these issues have forced political and organizational scholars to re-evaluate our approaches to management in general. While control-based management had its place in this century, its time seems to have passed.

Information - Incredible amounts of information can be literally at our fingertips if we have the technology. Computers and telecommunication systems allow anyone with the know-how to access or distribute information. Beyond the societal implications,

organizations can replace information people with information hardware/software. We can structure our organizations to include only those individuals that actually add value to our service or product. The continuing advances in information technologies allow this.

I am not implying that this explains it all. But beyond all the business jargon about re-engineering, flattening the organization, and creating virtual corporations, I do think these four elements and their interaction do explain why decentralization is the crux of organizational theory for the future. Handy describes our longstanding approach to civilization as one founded upon planning, managing, and controlling. This approach is evident in our organizations, our religions, our governments, and, most importantly, ourselves. While this approach worked in the past, our world is too increasingly complex for it to continue. I do not believe this approach can guide us on our new path. We need to create a new roadmap.

2.3 The Secondary Trends

Beyond the two more general dominant trends previously discussed, several trends more specifically associated with remediation are manifesting themselves. Again, an organization aware of these trends and their influence can prepare itself for the future. The following discussions document these trends:

- ***Shifting market needs***: Remediation clients vary tremendously in their needs and methods for cleanups. Since the majority of the remediation clients are also government agencies, the policy adjustments forced by changes in political leadership make these markets somewhat tenuous. Increasingly, the economic and public health justification for extensive cleanups is under scrutiny.
- ***Evolving liability standards***: Financial responsibility for costs of clean-ups and legal responsibility for personal injuries or property damages are consistently influenced by legislation and court decisions.
- ***Maturing technologies***: Ecological technologies are barely a decade old, and regulatory structures have hindered innovation. In addition, heightened public interest in remediation substantially affects the acceptance of technologies. Incineration, once considered the crux of remediation technologies, has become increasingly unpopular as an alternative. Further, indications that future public policy will incorporate land use provisions and cost efficiency as remediation criteria suggest greater emphasis upon containment rather than cleanup technologies.

- ***Increasing interest in the ecology***: Society has shown a strong interest in maintaining our ecology for future generations. In 1990, a CBS/NY Times poll indicated that 75% of the respondents agreed that protecting the environment is so important that the requirements and standards cannot be too high, and continuous environmental improvements must be made regardless of cost.

2.3.1 Shifting Market Needs

Client needs and relationships in remediation are quite diverse. Private work has remained slow since PRPs appear more apt to battle clean-up responsibility on legal venues and wait for Superfund reauthorization which remains mired in legislative debate and almost lost among the variety of issues confronting the nation. Still, Superfund changes under consideration include land use provisions, presumptive remedies and flexible RODs where designs are not stoneclad, and "hot-spot strategies" to prioritize cleanup sites.[12] R. Stephen Maxwell, President of TechKNOWLEDGEy Strategic Group in Boulder, CO, expects the dawn of improved understanding of ecological risks in the future since "perceived" rather than "real" risks have influenced public policy. He comments:

> *The emphasis in public policy seems to be shifting away from those problems which represent a potentially high impact for a relatively small or narrow receptor population, toward problems which may represent lower potential individual danger but which may widely impact human populations...ten years ago the cleanup of hazardous waste sites was thought to be critical from the perspective of human health...Now, most people realize that there are often far more pressing needs for limited public environmental expenditures.*

As public policy shifts to emphasize realistic economic and public health cleanup decisions, future remediation market needs will demand cost efficient solutions. Couple this emphasis with the increasing interest in land use provisions and "hot spot strategies", and I expect a shift in demand toward containment rather than cleanup services.

Today, the largest sector of work is for public clients, particularly for DOD. Recent contracting approaches indicate a greater emphasis upon turnkey projects and cost-plus contracts. The volume of work provided by DOD awards has forced consolidation throughout the industry. Firms have scaled up through mergers and acquisitions to compete for large-scale government work. Small acquisitions and merger transactions are

[12]EBI. "Site Remediation Markets", Environmental Business Journal, August 1994, p. 3.

occurring on a monthly basis.[13] Further, project management at DOD sites is under extreme scrutiny. Cost reimbursable contract vehicles have increased the influence and extent of DOD contracting officers. In the US Corps of Engineers New England Division, the contract/project management force has increased approximately threefold, and their roles have changed from monitor to supervisor.

In addition, some project teams are rather intricate. For example, at the Baird & MacGuire Superfund site in Holbrook, MA, the remedial action contractor, OHM Remediation Services, Inc., must coordinate relationships with the EPA acting as the owner, the U.S. Army Corps of Engineers acting as a consulting construction manager to the EPA, and Metcalf and Eddy acting as the remedial designer. Additionally, depending upon the site, a wealth of differing processes may interact in the whole remedial system in place to clean-up contamination. At the New Bedford Superfund site, the general contractor coordinated and managed support area construction, construction and operation of a waste water treatment plant, placement of air monitors, dredging of approximately 10,000 cubic yards of highly contaminated sediment, mechanical dewatering, thermal drying of dewatered sediments, incineration, ash handling and testing with solidification if necessary, on-site ash storage and construction of a permanent cap over the ash storage area. This intricate system for remedial action requires an experienced team to manage it.

Finally, the choice of clients can have farther reaching implications than merely differences between handling one type as opposed to another. For example, at the Bridgeport Rental and Oil Services Superfund Site in Logan Township, NJ, the general contractor, ENSERCH, found itself in a potential conflict of interest. The US Department of Justice directed them to use extreme caution during the site clean-up to preserve evidence for future prosecution of potentially responsible parties (PRPs). Privately, ENSERCH worried that some of the PRPs are current or future clients. Their adherence to the Department of Justice's edicts could place future client relationships in jeopardy. While this is a unique case, it only highlights the necessity of a thorough project evaluation before the bid process.[14] Additionally, remedial actions are oftentimes begun before consent decrees are agreed upon by PRPs because of the immediate threat a site might impose upon human health. Subsequently, current and future clients might view a

---

[13]TechKNOWLEDGEy Strategic Group. "Update on the Commercial Environmental Services Industry", September 1994, p. 2.

[14]Rubin, D. "EPA's Problem-child Superfund Site Shows Signs of Improved Behavior", ENR, April 25, 1994, p. 42-43.

construction organization as a member of the "establishment", a stigma which is not easily shaken.[15]

2.3.2 Evolving Liability Standards

The potential liabilities in remediation seem almost endless, but they, generally, can manifest themselves in two ways:

- financial responsibility for the costs of cleanup
- legal responsibility for personal injuries or property damages

Superfund legislation imposes considerable financial liabilities on those considered potentially responsible parties (PRPs); PRPs can range from the current owners of a facility at the time of disposal or release of hazardous substances to those who arrange for treatment or disposal of hazardous substances at a facility. This broad definition of PRPs makes remediation work rather tenuous. General contractors performing cleanups can possibly find themselves financially responsible for them. Further, under CERCLA the government may invoke strict, joint and several liability statutes in its handling of PRPs. Joint and several liability means that each and every PRP at a site where the injury is indivisible may be held individually liable for the entire cost of the cleanup. Strict liability means that the government does not have to prove any intent or negligence on the part of PRPs, so the law can hold PRPs liable without regard to intent or fault. Fortunately, SARA added statutes of limitations for recovery of cleanup costs for both removal actions (emergency responses) and remedial actions (long-term solutions). The initial action for recovery costs must begin within three years after a removal action is completed or within six years after physical on-site remedial activities begin for a remedial action. Under RCRA corrective actions, the party responsible for the release of the hazardous substance must pay for its remediation.

This year Superfund is scheduled for reauthorization, and pending legislative changes to it are paramount to the remediation industry. Resounding clamors for reform from government officials and private industry echo across the nation. Private industry wants some measure of certainty to what they now view as a capricious program, while ecological groups are wary of unfounded changes. Ecological activists recognize, however, that left unaltered the existing program will not remedy the current

[15]Dan Crews, a Ph.d. candidate in the Department of Civil and Environmental Engineering at MIT, is responsible for this insight.

contamination problem.[16] Still, the Clinton administration is scrambling to shuffle the bill through Congress. Efforts were underway to build consensus among key stakeholders to insure the bill's survival, but its passage during the 1995 Congressional sessions is still unpredictable.

Although Superfund itself does not impose liability for personal injury or property damage, SARA made it easier for citizens to sue PRPs for such damages, commonly referred to as toxic torts. Legal remedies for those affected by a remediation project include trespass, nuisance, negligence and strict liability. A party may invoke trespass laws if a stretch of land is invaded physically by a substance. For example, a site with a contaminant that invades groundwater may migrate into nearby wells or local sources of water. Subsequently, those injured could recover damages from the responsible party. Nuisance laws defend a property owner from interference or disturbance from activities on another's property. Negligence requires the plaintiff to prove that the defendant was required to conform to a specific standard of due care, that the defendant failed to do so, an injury occurred, and the lack of due care was the immediate cause of the injury. Finally, strict liability offers a variety of options for those injured. Defendants can be found liable for "non-natural" uses of land or "ultra hazardous" activities. While the majority of legal actions are taken against organizations, individual liability--organization employees and managers--is not uncommon.[17] Certainly, RCRA corrective actions could result in similar claims of damages. The latent aspect of these liabilities makes them the most dangerous. Conceivably, a citizen could sue a PRP or a facility that treats, stores or disposes (TSD) of hazardous wastes for an eternity.

Shifting liabilities create several dimensions for consideration by remediation organizations. Obviously, health and safety issues are significant; properly training and protecting the workforce can minimize their risk of exposure to hazardous wastes. This might further minimize the potential for future liability and reduce worker compensation and insurance costs. In addition, training and protection can insure the safety of the surrounding community. Project selection is an additional process to minimize risks. The scope and size of projects can insure that potential rewards outweigh the necessary costs. While larger projects provide greater sources of revenue, they also guard against the potential for future liability. A $1 million project could conceivably carry as much future liability as a $50 million project. Further, during acquisition decisions, the acquiring firm

---

[16]Ember, L. "White House Makes Heroic Effort to Get Superfund Renewed This Year", Chemical & Engineering News, May 9, 1994, p. 23-24.

[17]This discussion of trespass, nuisance, negligence and strict liability is taken from: Hoffman, A. "Risky Business: Commercializing Remediation Technologies Fraught with Incentives, Obstacles", Hazmat World, February 1992, p. 48-49.

must consider more than the considered firm's current liabilities. Again, the latent aspect of remediation liabilities requires evaluation of the firm's entire project history with emphasis upon its potential for future litigation.

Appropriate contracts can further attenuate liability by properly affixing responsibility. The implications for alternative contracting methods for a given project are twofold. One, a general contractor should consider the designer's qualification and project history. A designer with an impeccable reputation bodes well for less flexible contracting alternatives and vice versa. Second, the general contractor should conduct a thorough evaluation of the project characteristics such as the type and location of the contamination and existing public interest and possible future interest in the project. If the project is complex, then the contract should remain flexible. This axiom should be balanced, however, against how much information the contractor can ascertain prior to the bid process. As more detail is acquired, the less uncertainty involved. For example, a firm fixed price contract may initially appear unattractive. Given the nature of remediation work and the potential for unknown contaminants at sites, a general contractor might shy away from a fixed price contract. If the contractor has done a thorough evaluation of the project and is confident that the proposed design can effectively cleanup the contamination, then a fixed price contract may not be inappropriate. Finally, the contractor must demand adequate change conditions in the contract to protect itself from unforeseen circumstances.

The MOTCO Superfund site near Galveston, TX demonstrates wonderfully the implications of contracting decisions. In 1988, International Technology Corp. (IT) won a $30 million contract from Monsanto Corp. and four other PRPs at the site to incinerate 64,000 cubic yards of waste. The remedial design was prepared by Woodward Clyde Group Inc., and Monsanto officials claim that all bidders were also invited to investigate the site themselves. Assistant General Counsel Thomas M. Bistline for Monsanto states: "*This was a fixed bid contract and the risk was placed on the contractor so it needed to know.*" Bistline further claims that IT agreed in writing that it was satisfied with the assessment. As IT began work at the site, it discovered that the wastes were primarily contaminated soils and sludges and not the expected oily and liquid wastes. The soils and sludges will not burn as well, so IT sought a change order to raise the value of the contract to $95 million. Monsanto would not agree to these changes although IT thought it had received an informal agreement in September of 1991. The two firms were locked in a legal battle until April of 1994 when a court awarded IT $81 million in damages.[18]

---

[18]Details of this case were taken from: Powers, M. and Rubin, D., "Superfund Proves Risky for IT-and Others", ENR, April 20, 1992, p. 32, and Powers, M., "Jury Rules for Cleanup Firm", ENR, May 2, 1994, p. 8.

While the contractual and situational issues were haggled over in court, this example demonstrates the significance of the contract dimension. Before entering into a fixed price contract, a general contractor must either have confidence in the designer responsible for developing the solution, have access to the site to perform its own assessment, or insure the necessary change conditions are stipulated in the contract. Fortunately for IT, the jury found Monsanto guilty of fraud by breach-of-contract. Although Monsanto continues to argue that their RFP was a "mere estimate" of the waste at the site, IT counters that its the waste generator who is responsible for the waste it produced and cannot shift this responsibility by a contract to the remediator.[19] The jury in this case agreed with IT, but Monsanto plans to appeal the decision. Still, IT might have avoided the continuing and costly legal battle through a better evaluation of the project.

2.3.3 Maturing Technologies

Until recently, wastewater treatment was nearly the only ecological technology. Today, ecological technologies are so numerous that they require further classification, such as remediation or pollution prevention technologies. Remediation technologies range from thermal treatment methods to bioremediation, and efforts are underway to continue their development. They continue, however, to mature in a variable medium. Once considered the crux of remediation, incineration is increasingly scrutinized by public interest groups, becoming less and less plausible as an alternative. For example, the EPA's record of decision (ROD) at the New Bedford Superfund Site in MA called for the dredging of over 10,000 cubic yards of contaminated sediment from the harbor, mechanical dewatering, thermal drying of dewatered sediments followed by their incineration. A general contractor was awarded the job, and dredging of the harbor began in April of 1994. Meanwhile, citizens from the local community rallied an effort to block the incineration. In June of 1994, the EPA reversed its ROD, choosing not to have the dewatered sediment incinerated. Now, the contaminated sediment will sit in a temporary storage container until the EPA re-evaluates the situation which will certainly take several years.

Technology developers face substantial regulatory risks from changing public policies. Once developed, a technology may become obsolete because of regulatory changes or shifts in public opinion. Today, incineration is questionable as a viable technological alternative, and previously we discussed the likelihood of containment rather than cleanup

[19]Powers, M., "Jury Rules for Cleanup Firm", ENR, May 2, 1994, p. 8.

technology use as future remediation decisions and regulations incorporate land use, economic, and broad-based public health considerations. In addition, financial risks abound for technology vendors and users, foremost of which is the danger from legal judgments. The tenuous liability issues in remediation work transcend normal project durations extending into an uncertain future. While efforts are underway on the legislative front to reduce this obstacle, the commercialization of remediation technologies is still an arduous process. Further, once developed, they must withstand tremendous scrutiny, as the New Bedford example attests, and regulatory changes.

2.3.4 Increasing Interest in the Ecology

Public interest has grown dramatically. For example, in 1982 membership in the nation's sixteen largest ecological groups numbered under 6,000,000. In 1993, membership had grown to nearly 12,000,000; about a 100% increase.[20] Coupled with this growth are voluntary efforts toward industrial transformation. Two well-known efforts that we have already discussed are the CERES Principles and CMA's Responsible Care. Given that the nature of remediation is ecological restoration, further damage to the ecology during remediation is definitively undesirable. Certainly, this is an operational issue to insure that the procedures followed and the equipment used maintain ecological integrity. An additional decision facing remediation organizations is should they implement their own programs aimed at institutionalizing ecological considerations into their activities. Traditionally, construction organizations market "no-nonsense" services that are timely and at minimal cost. This approach somewhat conflicts with ecologically considerate activities which extend beyond compliance. Certainly, ecological stewardship requires exceeding minimum standards and will increase costs. Do remediation clients want this? In 1992, Morrison-Knudsen Corporation hinted at its own emphasis on environmental stewardship calling itself "*a trustee of environment, not only in its remediation work for clients but also in its own operations*".[21] Whether this statement indicates real action within the organization or is merely a marketing ploy is difficult to discern. In any event, Morrison-Knudsen felt the need to inform their clients and stockholders of this. Second, the make-up of a specific project's workforce could increase or decrease the likelihood of further ecological degradation. This is primarily a decision in

[20]Hoffman, A. The Environmental Transformation of American Industry: An Institutional Account of Organizational Evolution in the Chemical and Petroleum Industries. Doctoral Thesis submitted to the Sloan School of Management and the Department of Civil and Environmental Engineering, MIT. Cambridge: February, 1995.

[21]Morrison Knudsen Corporation, Annual Report, 1992, Boise, Idaho, p. 4.

the qualification of subcontractors, not unlike normal decisions for construction work. No matter, the decision should certainly include their project history and their record of litigation and performance. Finally, ecological stewardship might ease relations with the public and environmental groups during remediation projects. Demonstrating their own efforts toward *real* change may assist remediation organizations in their public relations efforts.

2.4 Summary

This chapter provided some essential information for the creation of an organization's foresight, a necessary understanding of the pertinent trends affecting one's business. With foresight, an organization can harness the trends and establish its place in the competitive environment. Generally, two dominant trends are influencing the remediation industry: decentralization and sustainable development. Decentralization is a trend in business management that emphasizes flexible organization through competency discovery, development, and complementation, lateral coordination, and autonomous decision-making. Sustainable development is a direction in ecological management that emphasizes economic and ecological harmony. Specifically, several secondary trends are affecting the remediation industry directly. Shifting market needs, evolving liability standards, maturing technologies, and increasing interest in the ecology all have significant implications upon remediation work. Our attention shall shift in the following chapters to the secondary trends, more directly associated with remediation, as we discuss remediation markets, approaches to risk management, and technological development and transfer. We shall return to a discussion of the more general trends in the final chapters.

Chapter 3
REMEDIATION MARKETS

Every individual endeavors to employ his capital so that its produce may be of greatest value.

- Adam Smith

3.1 Overview

When Superfund and RCRA legislation virtually created the cleanup market, initial estimates of the volume of cleanups necessary dramatically grew into figures of several hundred billion dollars. Hurriedly, hazardous and solid waste management, construction, and defense contracting firms diversified into the promising market. Today, the public and legislators are beginning to question whether this enormously expensive effort is economically and medically justified. Superfund legislation remains in limbo, DOE is jumbled in managerial and acquisitional chaos, and the nation's mood has dramatically altered as evidenced by the November 1994 elections. Seemingly, the only non-stagnant segment of the market is within DOD. As the next century approaches, I expect that we shall see more emphasis upon site containment rather than cleanup particularly in remote areas. Public clamors for reduced government influence and spending will force a change in the current Superfund legislation toward more cost effective solutions. No doubt, ecologists will oppose such efforts, but I expect an indicator of the shift will be the 1996 Presidential election. If ecological issues drop from the agenda of debate, the shift is underway.

Still, the remediation market will continue to provide substantial revenue for firms providing quality and responsive services well into the next century. In the past, client attitudes have focused upon damage control. Remediation clients most certainly did not want to pay for cleanup services. Quite often, they were forced to do so. Accordingly, they generally avoided cleanup responsibility, and when required to implement them, they spent as little as possible. The damage control philosophy resulted in tremendous litigation and cleanup delays. Accordingly, remediation clients wanted low-cost solutions. Today, this damage control philosophy still exists, but the client is more interested in value than low-cost. As Metcalf & Eddy President and CEO Don Deieso comments, "Customers have been buying cheaply; in the future, customers will buy economically."[22]

[22]EBI. "Site Remediation Markets", Environmental Business Journal, August 1994, p. 4.

3.1.1 Market Characteristics

The remediation market is dominated by regulatory influence. It is virtually impossible to conduct a cleanup without either regulatory governance or influence. Suppose a private firm has an accidental spill of hazardous waste. This hypothetical firm wants to clean up the spill to avoid spread and to enhance its reputation in the community as a responsible company. The firm now subjects itself to the rigorous RCRA corrective action process with its land disposal restrictions, minimum technology requirements, permitting procedures and review process. Sound complex? Well, it is and rather lengthy. The influence of CERCLA (Superfund) dwarfs RCRA. Superfund criticisms include its inflexibility, misplaced liability, and inefficiency. Some efforts, however, are underway to ease the process or to allow states to implement cleanups; we shall discuss these later in the chapter.

Beyond regulatory influence, several developments are shaping the future of remediation. Most states require ecological audits during property transfers. This forces cleanups in many cases. Additionally, the August 1994 edition of the *Environmental Business Journal* highlights some recent developments. Securities and Exchange Commission proposals recommend the report of contingent liabilities and the expected result of remedial liabilities on publicly traded company balance sheets. Such a requirement might certainly prompt more proactive cleanup strategies by private parties. Some development firms are purchasing devalued contaminated property, partnering with remediation vendors, and cleaning it up as an investment. These developments provide promise for the growth of voluntary cleanups.

Finally, the *Environmental Business Journal* forecast $6.4 billion in work for 1994, promising an annual growth of 5-7% over the next five years. A variety of clients require remedial work. EPA-governed Superfund sites on the national priorities list number in the thousands, and the EPA has enlisted the US Army Corps of Engineers to manage many of their cleanups. The Department of Defense (DOD) has over 7,000 sites requiring cleanup.[23] Add the Department of Energy (DOE) to this governmental mass and the market's client diversity increases, but the diversity does not stop here. State environmental agencies also oversee cleanups, and PRP groups or voluntary cleanup clients include members of the petroleum, chemical, automobile, and computer/electronic industries, to mention a few. Complementing the diverse client base is an equally diverse

[23]Sullivan, J., CEO and President of Perland Environmental Technologies, Inc., Speech delivered at MIT on March 4, 1994.

competitor pool that includes general contractors, waste managers and defense contractors. Indeed, this market appears rather grand.

3.1.2 Market Segments

Remediation clients are either public or private; Federal and state EPA's, the DOD and the DOE are the principle public-sector clients. Within DOD, the Army, Navy and Air Force handle their own cleanup efforts. The US Army Corps of Engineers takes a multi-dimensional role for the Army. It may handle the Army's cleanups or it has acted as the client's representative for the EPA and the DOE. In the private-sector, clients are generally PRPs responsible for Superfund cleanups, firms implementing RCRA corrective actions, or firms initiating voluntary cleanups. Other private-sector work might involve cleanups incident to real estate development or underground storage tanks (USTs). Normally, remedial work has several phases. Initially, a contaminated site is discovered by some party. Upon discovery, a *preliminary assessment* and *site investigation* are usually conducted to determine the site's history and to conduct a field study. If the site warrants further action, it undergoes an in-depth *remedial investigation* to further understand site characteristics. Next, a *feasibility study* is undertaken to evaluate potential options for action. Once complete, an option is chosen, and engineers create a detailed *remedial design*. Finally, the design is implemented through *remedial construction* or *action*.

To meet the growing demands for remediation, client services are offered in eight categories: characterization, analytical, design, construction, construction management, specialty, technology or closure and monitoring. I define characterization services as those that provide preliminary assessments, site investigations, remedial investigations, or feasibility studies. Analytical services augment characterization or design services by offering laboratory analysis of site specimens. Design services will provide geotechnical, hydrologic, toxicological or ecological plans and solutions for implementing cleanups. Obviously, construction services will supply the necessary physical activities for site cleanups, and construction management services will offer expertise in coordinating and supervising construction activities. Specialty services might include hazardous waste transportation, storage, and handling or UST testing, removal or installation. Technology services are provided by remediation technology vendors that offer such alternatives as incineration, soil vapor extraction or bioremediation. Finally, closure and monitoring services provide the necessary elements to maintain a remediated site. Our interests are primarily with those firms that provide characterization, design, construction and construction management services (some attention will be given to technology services).

For our purposes, I classify firms as either sole service contractors or full service contractors. Sole service contractors are either remedial engineering or remedial construction firms. I define remedial engineering (or engineering) firms as those who offer characterization and design services and remedial construction (or construction) firms as those who offer construction or construction management services. Full service firms are remedial engineering/construction firms that provide characterization, design, and construction services (some sole service or full service firms may also engage in technology services).

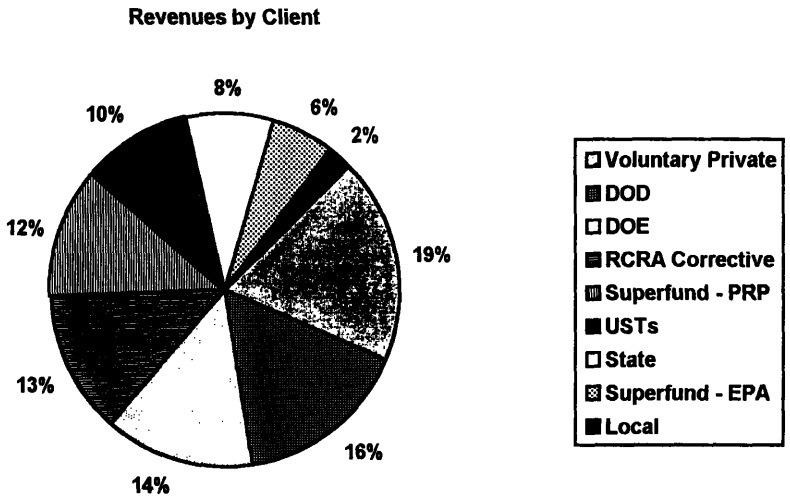

Figure 2. 1993 Market Revenues by Client
Source: Environmental Business Journal, August 1994

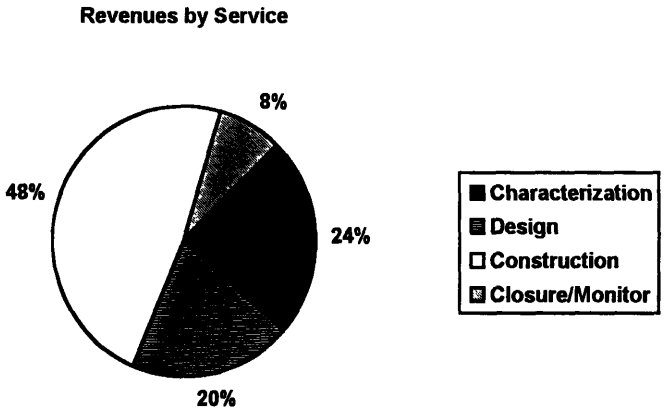

Figure 3. 1993 Market Revenues by Service
Source: Environmental Business Journal, August 1994

Figures 2 and 3 highlight 1993 revenues by client and service. Voluntary private, DOD, and DOE accounted for nearly half the client revenues while construction similarly provided nearly half the service revenues. Additionally, the industry has seen tremendous

consolidation recently. James Cleveland, President of Stone & Webster Environmental Technology & Services, commented during a recent seminar at MIT that over thirty mergers have occurred in the past year. Firms are scrambling to "reinvent themselves into bigger permutations that are better equipped to tackle large-scale government work."[24] The remainder of this chapter will examine the clients discussed above in greater detail giving special attention to federal clients such as DOD and DOE.

3.2 Federal Clients

Federal markets might prove stable or volatile depending upon the mood of the nation. In the 1980s, stability was the watchword. The Republican Party dominated the political scene for twelve years. Policy changes were minimal. In 1992, the country signaled clearly its desire for a new direction as the Democrats ousted them from office. Our form and system of democracy creates market paradox. Implementing a policy change requires mass consent, but our system of government replaces or confirms its representatives every few years. Depending upon the diversity of our representatives, policy changes are either often or rare. President Clinton quickly appointed Carol M. Browner as head of the EPA and elevated it to cabinet status, but ecological issues have gotten lost amongst debates over health care, crime and international affairs. Resolving the nation's Superfund and RCRA issues became lower priorities.

Rumblings in Washington about federal procurement strategy, policy and operations, however, predict a volatile front for future contracting with the federal government. In late August of 1994, the Senate approved a bill that would overhaul the country's purchasing program, and the bill was on its way to the House; the Office of Federal Procurement Policy (OFPP) has launched several pilot projects aimed to encourage agencies to consider past-performance criteria during contract awards, create incentive-based contracts and promote alternative dispute resolution; and finally, the OFPP plans to rewrite the Federal Acquisition Regulations. The prevailing goals of this reform agenda are threefold: first, the administration wants to give more flexibility to its contracting officers; second, it desires to make the acquisition system less cumbersome; and third, it plans to base contracts upon performance-fee criteria. Overall, these initiatives are targeted at creating a more efficient system. Steven Kelman, the White House administrator for federal procurement policy, warns that "we're on a hundred-step journey, I think right now we're about at step four".[25] Indeed, the pending changes in federal

[24]EBI. "Site Remediation Markets", Environmental Business Journal, August 1994, p. 6.
[25]Ichniowski, T. "Driven to Reform", ENR, September 5, 1994, p. 84.

procurement policies add fuel to an already complex and maturing federal remediation market.

3.2.1 The US Environmental Protection Agency

Generally, US EPA acts as either the client or the regulating authority for cleanups. When the EPA assumes the client role, it, more often than not, is executing a fund-financed cleanup under CERCLA. Normally, a fund-financed cleanup will occur in three situations: 1) following the site inspection, it is determined that an immediate threat exists to public health or the environment; thus, the EPA initiates an emergency response called a removal action; 2) the EPA initiates cleanup efforts, and the government will seek reimbursement later; or 3) no responsible party with efficient funds can be found to conduct the cleanup. In its regulatory capacity, the EPA oversees cleanup efforts conducted under Superfund or RCRA corrective actions. In either capacity, critics charge the EPA as inefficient. While some of these inefficiencies are inherent in the legislation, EPA permitting and approval processes are slow. Special interests from both industry and ecological groups battle daily to have Congress hear their voice. Industry clamors for reforms in legislation and administration to speed the process, develop cleanup standards, reduce liabilities, and create flexibility. Ecological groups fear loosened reigns will result in improper and incomplete cleanup efforts. As previously discussed, the reauthorization of Superfund is uncertain for 1994, and reform of RCRA is not on the current legislative horizon.

My intent in this section of the chapter is not to haggle over who's right or wrong in this struggle or predict the future of Superfund or RCRA legislation. Instead, I hope to highlight some significant developments that might assist remediation organizations to plan for the future. Recently, EPA has implemented several initiatives that might signal future trends in EPA-lead or regulated contracts. In 1992, the Superfund Accelerated Cleanup Model (SACM) was implemented on a pilot basis. The model separated the Superfund process into early actions taken to reduce risk and long-term actions for site restoration. Essentially, SACM combined the preliminary assessment and site investigation process into one expanded phase. Following this action, a regional team decides whether the site requires an early removal action or long-term remediation. Further, EPA developed presumptive remedies for particular site categories such as wood treatment facilities and municipal landfills. The intent is to reduce the length of the

remedial investigation and feasibility study phases that have proven exhaustive.[26] If SACM were implemented nationwide, contractors might expect an increase in smaller cleanup projects as removal action contracts become more prevalent. Medium to small sized remediation firms might find significant opportunities, and through my discussions with members of remediation organizations, some already note this trend. One senior manager indicated that projects under $1 million are dominating the market. In addition, the presumptive remedy approach lessens the importance of characterization services and might provide the opportunity for contractors to specialize in specific site cleanups. For example, a contractor could gain experience in wood treatment facility cleanups and develop a cost-effective approach as a competitive advantage.

In Tacoma, WA, one of the first land-use strategies is on-going under Superfund. Asarco Corporation, based in New York City, is leading a team effort between themselves and city officials to cleanup an abandoned metal smelting site and re-develop it into a series of parks, homes, and industrial plants. The site is contaminated by 220,000 tons of soil laced with arsenic and lead. Initially, EPA planned to dispose of the soil off-site, a plan that could cost Asarco Corp. up to $100 million according to company officials. With the community's support, Asarco has convinced the EPA to consider an on-site landfill proposal, estimated at $40 million. Under the plan, Asarco would landfill and cap the existing contamination and cover it with a grassy traffic circle. The EPA is considering the proposal. If the EPA approves the plan, this may signal cost-savings opportunities for other PRPs by following a similar strategy. For contractors, this may increase the importance of value-engineering for potential clients. In 1988, Perland Environmental Technologies, Inc., a subsidiary of Perini, entered the remediation business with such a strategy. It hoped to attract PRP groups by offering services to identify the cost-drivers in a project and determine cost-effective alternative solutions. While the environment was not ripe for such a strategy then, this project in Tacoma may signal its time has come.

Finally, the EPA developed two new categories of contaminated sites called corrective action management units (CAMUs) and temporary units (TUs) in 1993. Both categories are regulated under RCRA; a CAMU is a parcel of contaminated land within a RCRA site that may be cleaned up under less stringent rules than usual standards. Primary highlights are its allowance of non-contaminated land in the CAMU area, allowance of more than one CAMU at a facility, allowance of ex-situ treatment of waste, and less stringent criteria for triggering land disposal restrictions (LDRs) and minimum technology requirements

[26]Simon, J. "A Technical View: New EPA Developments to Streamline Site Cleanups", Environmental Permitting, Winter 1992/93, p. 68.

(MTRs). Peter Tunnicliffe, President at CDM Engineers & Constructors, Inc., believes that these changes will result in greater use of innovative technologies and better site management since areas exist for staging and materials storage. The only catch is that designating a CAMU requires review and approval by the EPA Regional Administrator. Given the track record of EPA's approval processes, the outlook for efficiency is dim. The TU designation applies to tanks and container storage units in use to assist facilitating cleanups. Facilities may employ TUs for one year, and their design, operation and construction remains contextual for review by the EPA Regional Administrator. Now, public review and comment is required, however, since TUs are allowed for one year. How this requirement affects the timeliness of cleanup execution remains to be seen. Contractors may see an increase in remediation efforts by private facilities because of these initiatives. Again, the initiatives favor medium to small-sized firms since the scope of work for CAMUs will be limited. Further, the ex-situ treatment allowance hurts the already beleaguered off-site disposal vendors since soil can be excavated, treated and replaced.[27]

In this section, I have pointed out several developments within the EPA that may change the nature of remediation in the near future. An evident trend is the potential for greater cleanup efforts initiated by private industry. If this trend continues, value-engineering services may become more significant for remediation firms. While private industry already places substantial pressure upon contractors to provide cost-effective services, the demand will increase. A remediation firm that can develop and market such skills acquires an advantage. Additionally, smaller projects are becoming increasingly prevalent. While larger remediation firms are not positioned for work in this market segment, a subsidiary or new division could provide revenues while the large project market sorts itself out.

3.2.2 The US Department of Defense

In 1986, DOD established the Defense Environmental Restoration Program with its primary goal as "the identification, investigation, research and development, and cleanup of contamination from hazardous substances, pollutants, and contaminants." With the end of the Cold War, base realignment and closure became commonplace. Clearly, DOD's cleanup efforts are focused upon base closures. Not only is this their civic responsibility, but it also returns land, often prime real-estate, back to the community.

[27]Tunnicliffe, P., Walsh, C. and Roth, L., "Faster Cleanups: Can a CAMU Do What It's Supposed to?", ENR, Special Section on Environmental Engineering, June 14, 1993, p. E-30.

This aspect places their efforts under tremendous scrutiny by Congress and the public. While numerous military sites are on the NPL, all military cleanups are financed by DOD. Accordingly, DOD has maintained substantial autonomy in its cleanup efforts. This autonomy is further substantiated by the military's substantial experience in construction contracting and management. Initial estimates of the resources necessary for completing DOD's cleanup were around $200 billion. For FY95, DOD plans to spend $2.7 billion for environmental restoration, a 5% increase over the FY94 appropriation. Indeed, DOD restoration appears promising, but an *Environmental Business Journal* survey rated DOD as the least profitable market, only providing an average return of 8.6%. Still, the magnitude of the effort necessary and the proactive cleanup approach makes DOD a lucrative market for the near future.

3.2.2.1 The US Army

By far, the US Army has the majority of DOD sites requiring restoration. Nearly 60% of DOD's sites are the Army's responsibility.[28] A unique element of the Army is its Corps of Engineers (USACE). The Corps has assumed the role of the nation's engineers for years. Over time, it has developed an unmatched skill in contracting and managing public construction, so USACE manages the Army's cleanup efforts. The Corps is organized into nationwide districts; each district is responsible for administering its region's cleanup efforts. Not surprisingly, the Corps has also been called upon by both EPA and DOE to manage cleanup efforts for them, a role it does not take lightly. At the BROS Superfund Site in NJ, the Corps is managing the project for the EPA while DOD is a possible PRP. When asked if this is a conflict of interest, LTC Richard Sliwoski, chief engineer of USACE's Philadelphia District, responded "I work for EPA."[29] At the same site, the Corps threatened to rebid the cleanup contract in 1992. This forced the contractor to take drastic action that saved the job but resulted in breach-of-contract lawsuits with its subcontractors. Certainly, the USACE is a sophisticated client.

Contracting Methods - Until recently, USACE contracted cleanups as it would have any other construction activity by letting and awarding fixed price contracts for each phase of remedial work. Different contractors were selected to conduct the characterization, design, and construction activities required. Now, USACE has adopted what it calls Total

---

[28]Defense Environmental Restoration Program, Annual Report to Congress for FY91. US Department of Defense, February 1991.

[29]Rubin, D. "EPA's Problem-child Superfund Site Shows Signs of Improved Behavior", ENR, April 25, 1994, p. 43.

Environmental Restoration Contracts (TERCs) as its primary vehicle for large scale remediation contracts. TERCs allow a single prime contractor to provide full cleanup services at an installation through indefinite delivery/indefinite quantity contracts with cost reimbursement plus negotiated fee delivery orders for various elements of the Corps. Essentially, the prime contractor assumes turnkey responsibilities which is expected to hasten the cleanup process. This method was implemented in response to mounting pressures from Congress to speed military cleanups. TERCs are expected to account for roughly 25% of the Corps' environmental programs.[30] A substantial implication of this approach is that it dramatically narrows the competitor pool. In fact, a proposal investment might average $500,000. This does not mean that the Corps hopes to eliminate smaller firms from competition. Don Robinson, chief of the contracting division in USACE's Omaha District, emphasizes the Corps commitment to small and disadvantaged business by stressing their representation on project teams in preproposal conferences. TERC evaluation criteria stress business management and technical approach, past performance record, operational plan, acquisition plan, and cost. Cost-plus fixed fee or cost-plus award fee arrangements are generally employed in TERCs.

Contract Awards - USACE has awarded seven TERCs since late 1993 with an eighth currently pending. The following table summarizes information about these contracts:

Firm	*Services;Revenue (millions)**	*Region*	*Scope*	*Amount (millions)*
Rust International	E/C; $400	Mississippi River	C- RC	$200
IT Corporation	E/C; $170	AF, Atlantic: VA-GA	C- RC	$150
Rust International	E/C; $400	AF, Gulf: FL-TX	C- RC	$150
Ebasco Services^{+}	E/C; $1,200$^{\#}$	AF, SW: NM-CA	C- RC	$150
Ebasco Services^{+}	E/C; $1,200$^{\#}$	New England Div.	C- RC	$260
OHM&Wd. Clyde	RA&E; $242	SW Division	C- RC	$216
MK & SW	E/C; $231	SW Div., DOE	C- RC	$300

E/C: Engineering/Construction Services; E: Engineering Services; RA: Construction Services; C: Characterization; RC: Remedial Construction; *1993 gross remediation revenues unless # then 1993 total revenues; +Ebasco Services' environmental division was sold to Enserch Corp. and was then sold to Foster Wheeler

Table 2. USACE TERC Awards[31]

Source: USACE Environmental Restoration Division

[30]Parvin, J. "Army Tries TERCs to Speed Cleanups", ENR, Special Section on Environmental Engineering, November 22, 1993, p. E-8.

[31]Conventions for description of firm services, E, E/C, and RA; and scopes of work, C and RC, used in table 2 will be used in tables 3-6.

The Omaha District awarded TERCs to Rust, IT, and Ebasco. Ebasco's second TERC was awarded out of the NE Division. The Tulsa District awarded the final two TERCs to teams of OHM/Woodward Clyde and Morrison Knudsen/Stone&Webster. During competition for these awards, project teams took various forms; some were lead by engineering firms while others were lead by engineering/construction firms. Table 1 indicates that the Corps' preference for prime contractors is large engineering/construction firms.

Perspectives: USACE - In December 1993, USACE's New England Division awarded a TERC to what was then Ebasco Services, Inc. (Ebasco Services was sold to Raytheon minus its environmental division which became part of Enserch Environmental. Foster Wheeler acquired Enserch Environmental from Enserch Corp. in August 1994). Ira Nadelman manages the New England TERC for USACE. In a recent interview, he discussed the advantages and disadvantages offered by the TERC contracting method. Its primary advantage is its dramatic reduction in the time required to conduct cleanups. An example is provided by a congested site in Norwood, MA contaminated with primarily PCB's. Under the old method, the project might require five different contractors for cleanup completion. Aside from enhancing the site congestion problems by having multiple contractors working simultaneously, separate health & safety plans would have been necessary for each contractor. Both the congestion and redundant planning would have dramatically increased the time for cleanup. Nadelman points out that TERC allows single sets of project documents and health & safety plans for the site as well as one or two contractors to complete the work. TERCs also eliminate the continual bidding and transitions required under the old method. During the transitions, new contractors had to learn site specific information, Corps' operating methods, and the quirks of individual managerial relationships. Now, this learning occurs once. Finally, TERCs allow flexibility. Under fixed price contracts, site discoveries or conditions not covered required time consuming change orders or contract renegotiations. Now, the Corps can write contract delivery orders with flexible scopes of work that allow necessary changes as site conditions require them.

Nadelman points out that TERCs have altered the Corps' approach to contract management. Generally, TERCs place greater pressure on the Corps to oversee and monitor contractor work. Whereas before, schedule maintenance and specification compliance were the Corps' primary activities, now it must monitor contractor expenditures and methods to insure that they are appropriate. When necessary, the Corps will alter contractor plans to reduce costs or time. Nadelman needs a different type of

manager for these activities, and he figures that three managers are needed for TERCs for every one necessary under traditional contracts.

A disadvantage of TERCs often cited by its critics is its perceived lack of incentive for a contractor to minimize costs. Nadelman disagrees with this perspective for two reasons. First, when the Corps issues a delivery order, the fee is negotiated for somewhere between 3-10%. Once agreed upon, the fee is fixed. Nadelman argues that a contractor who runs up costs reduces his profit percentage since the fee does not change. He expects few contractors desire such a percentage reduction. Second, guaranteed work on TERCs is a small percentage of the award. For example, the NE TERC guarantee is only $300,000 of $260 million. Nadelman suggests that this provides ample motivation for the contractor to perform well (at least initially). A second disadvantage often cited and recognized by Nadelman is its bias toward large remediation contractors. He points out that the Corps is quite concerned over the role small and medium sized firms can have within the TERC framework. He expects the Corps to address this concern somehow in the near future.

3.2.2.2 The US Navy

Navy and Marine Corps sites account for roughly 13% of DOD sites requiring restoration.[32] The Naval Facilities Engineering Command (NAVFAC) is responsible for oversight of the Navy's restoration program. Similar to USACE, NAVFAC has nationwide Engineering Field Divisions (EFDs). Responsibility for contract administration generally falls under appropriate EFDs.

Contracting Methods - Over time, the Navy has adopted three basic types of restoration contracts: Comprehensive Long-term Environmental Action, Navy (CLEAN) contracts, Navy Energy and Environmental Service Agency (NEESA) contracts, and Remedial Action Contracts (RACs). CLEAN contracts are regional and administered by Navy EFDs. Generally, these contracts encompass characterization and design activities. Awards are for one year with nine option years. Awards are based upon Brooks Bill procedures, so selection is based upon technical merit. NAVFAC selected cost reimbursement plus fixed fee arrangements for CLEAN contracts due to the uncertainties of the work involved. NEESA contracts are contaminant specific remediation contracts for individual sites. RACs are generally cost plus fixed fee, indefinite delivery, indefinite quantity contracts. Work is accomplished by individual delivery orders that are placed by the Navy against each contract up to its ceiling amount. Delivery orders are either service

[32]Defense Environmental Restoration Program, Annual Report to Congress for FY91. US Department of Defense, February 1991.

or construction oriented. Service orders would require such activities as sampling, pre-construction work plans or pilot studies. Construction orders would require such activities as earthwork, disposal and treatment of contaminated soils, or installing monitoring wells. Originally, the Navy awarded RACs by contamination type such as PCBs or pesticides. Now, NEESA contracts have assumed this role for the Navy. RACs have taken on a broader scope of work to address multiple sites and contaminants. The RACs are administered by the same EFDs that awarded the study/design CLEAN contracts. RACs are awarded on a "best value" basis after evaluating factors such as technical capability, management ability, quality of human resources, experience with various types of ecological remediation, and proposed rates.

Contract Awards - NAVFAC has awarded ten regional CLEAN contracts since the first award in 1989 for a total of $1.8 billion in contract capacity. To date, NAVFAC has also awarded eight regional RAC contracts for a total of $1.9 billion in contract capacity. The following tables summarize information about these contract awards:

Firm	*Services;Revenue (millions)**	*EFD/EFA*	*Scope*	*Amount (millions)*
Jacobs Engineering	E/C; $944	SouthWest I	C - D	$260
Bechtel Environmental	E/C; $270	SouthWest II	C - D	$260
PRC Env. Mgmt.	E; $95	West	C - D	$260
URS Consultants	E; $68	EFA NorthWest	C - D	$166
ABB Env. Services	E; $81	South I	C - D	$175
Ensafe/Allen & Hoshal	unavailable	South II	C - D	$100
Ogden Env. & Energy	E; $84	Pacific	C - D	$100
Baker	unavailable	LD	C - D	$100
NUS	unavailable	North I	C - D	$130
EA Eng, Sci, & Tech	E; $54	North II	C - D	$100

D: Design; *1993 gross environmental consulting and engineering revenues unless otherwise noted

Table 3. NAVFAC CLEAN Awards

Source: NAVFAC HQ Public Affairs Office

Firm	*Services;Revenue (millions)**	*EFD/EFA*	*Scope*	*Amount (millions)*
Ebasco Environmental	E/C; $1,200#	EFA NorthWest	RC	$80
OHM Remediation	RA; $242	LD I	RC	$250
J. A. Jones	unavailable	LD II	RC	$75
OHM Remediation	RA; $242	Pacific	RC	$250
IT Corporation	E/C; $170	West	RC	$200
Bechtel Environmental	E/C; $270	South I	RC	$300
Morrison Knudsen	E/C; $231	South II	RC	$300
OHM Remediation	E/C; $242	SouthWest	RC	$250

*1993 gross remediation revenues unless otherwise noted; # Ebasco Services 1993 total revenues

Table 4. NAVFAC RAC Awards

Source: NAVFAC HQ Public Affairs Office

3.2.2.3 The US Air Force

The Air Force has roughly 25% of DOD's sites requiring restoration, and their approach is somewhat similar to the Navy's approach.[33] The Air Force contracts separately for remediation characterization/design and remediation construction.

Contracting Methods - The Air Force established the Air Force Center For Environmental Excellence (AFCEE) to manage its cleanup efforts. AFCEE awards contracts for characterization/remediation design (PA/RD: preliminary assessment through remedial design) and contracts for remediation construction (RA: remedial action). Beyond this distinction, contracts are either nationwide, installation specific, or intended for small businesses. Nationwide contracts have a cost ceiling, and work delivery orders can come from anywhere. Installation specific contracts either bundle several Air Force Bases into one contract or focus on a single installation depending upon the scope of work required. Here, work delivery orders come from the specified installations. Finally, AFCEE designated several installations exclusively for small business; the majority of these sites require underground storage tank removal and replacement.

Contract Awards - Recently, AFCEE has awarded ten nationwide contracts for indefinite quantity/indefinite delivery characterization and remediation design services. Each contract has a $50 million ceiling over a one year period with four additional one year options. Additionally, AFCEE has awarded two nationwide and sixteen installation specific remediation construction contracts. All the contracts are indefinite

[33]Ibid.

quantity/indefinite delivery awards under firm fixed price or cost plus award fee delivery orders for five years. The following tables summarize information about these contract awards:

Firm	*Services;Revenue* (millions)*	*Region*	*Scope*	*Amount (millions)*
Radian Corp.	E; $198	Nationwide	C - D	$50
Earth Tech. Corp.	E; $62	Nationwide	C - D	$50
Rust Env. & Inf.	E/C; $197^{+}	Nationwide	C - D	$50
CH2M Hill	E; $502	Nationwide	C - D	$50
IT Corporation	E/C; $260	Nationwide	C - D	$50
URS Consultants	E; $68	Nationwide	C - D	$50
Jacobs Engineering	E/C; 994^{\#}$	Nationwide	C - D	$50
Versar	E; $46	Nationwide	C - D	$50
Law Environmental	E; $49	Nationwide	C - D	$50
EA Eng, Sci, & Tech	E; $54	Nationwide	C - D	$50

*1993 gross environmental consulting and engineering revenues unless otherwise noted; $^{+}$1993 total gross revenues; $^{\#}$1993 total gross consulting and engineering revenues

Table 5. AFCEE PA/RD Awards

Source: AFCEE Public Affairs Office

Firm	*Services;Revenue (millions)**	*Region (AFBs)*	*Scope*	*Amount (millions)*
Jacobs Eng.	E/C; $162	Nationwide	RC	$150
OHM Remediation	RA; $242	Nationwide	RC	$150
Jacobs Eng.	E/C; $162	Castle, Chanute, Carswell	RC	$225
Mont. Watson	E; $62	Mather, George	RC	$190
Bechtel Env.	E/C; $270	Pease,Wurtsmith,Norton	RC	$290
Enserch Env.	E/C; $175	Grissom	RC	$40
OHM Remediation	RA; $242	England, Bergstrom	RC	$60
R&R International	unavailable	Eaker	RC	$30
BEM Systems	unavailable	Williams	RC	$30
Dames & Moore	E; $62	Richards-Gebaur	RC	$25
Env. Qual. Mgmt.	unavailable	Rickenbacker	RC	$25

*1993 gross remediation revenues

Table 6. AFCEE RA Awards

Source: AFCEE Public Affairs Office

Not surprisingly, engineering firms dominated the award of PA/RD contracts, but their size varied tremendously. Prime contractors for RA contracts were primarily engineering/construction firms.

Perspectives: Pease AFB Base Conversion Agency - Pease Air Force Base was the first major installation slated on DOD's closure list of December, 1988. Unfortunately, the installation had multiple sites contaminated with volatile organic compounds, heavy metals, fuel, and oil which lead to its listing on the NPL in 1990. Pease's cleanup is funded under DOD's Installation Restoration Program (IRP). Mark McKenzie, Environmental Engineer and Coordinator of the Pease IRP, has witnessed dramatic changes in the Air Force's approach to remediation work. Initially, the Air Force approached contracting for remediation work as it would have for its research and development contracts. The first remedial investigation and feasibility study (RI/FS) contracts had specific scopes of work and time/material payments. This approach slowed the cleanup process since RI/FS contractors were inexperienced and often requested contract change orders to expand their assessments. The Air Force reacted by broadening the scopes of work, and fortunately characterization at Pease was complete by late 1991. Initial remedial designs were awarded under specialty, lump sum contracts. As designs were completed, specialty, cost plus fixed fee contracts were awarded for remedial action. McKenzie commented that the cost plus fixed fee contracts have provided little incentive for the contractors to complete work under budget or time. In fact, problems have arisen with contractors attempting to "milk" contracts. In response, the Air Force contracting office has assigned a resident engineer to Pease for the specific purpose of contract and cost oversight. Additionally, McKenzie believes the piecemeal approach to contract awards has dramatically slowed the cleanup process since new contractors have taken time to assess the site themselves despite having prepared site information or designs. In addition, each new contractor has taken some time to become familiar with the Air Force representatives and procedures. McKenzie hopes to see the Air Force move toward cost plus incentive fee contracts, and he expects fixed price contracts are possible in the near future as the Air Force gains more experience in managing remediation and can prepare tighter scopes of work in their delivery orders. Further, he described their tendency to avoid delivery orders requiring design work. Instead, they have "skipped" them, and prepared construction delivery orders requiring proposals with greater detail in methods, materials, and shop drawings. This trend is consistent with the growing confidence both the Air Force and remediation construction contractors are gaining in their work and is further substantiated by a comment by Jim Malot, president of the remediation firm Terra Vac,

"We've worked on sites with two year designs three to six inches thick and used just six pages of it for the cleanup."[34]

3.2.3 The US Department of Energy

When I review the market characteristics of DOE, I cannot help but imagine a "sleeping giant". Total spending for restoration of its sites between 1992 and 1999 could reach $250 billion. Sites have chemical, radioactive, and mixed wastes, making them a unique managerial and technical challenge. DOE has proven a difficult client to serve, however, and Leo P. Duffy, former assistant secretary for environmental restoration and management at DOE, claims "the root cause of the problems is DOE's Jurassic Park procurement system."[35] While opportunities are abundant, the client and the wastes seem to present formidable challenges.

3.2.3.1 Past Management and Operation

DOE weapons sites have been traditionally maintained and operated by private contractors. These contractors, generally referred to as M&O contractors, handled the day-to-day business of the weapons facilities under DOE management. Throughout the Cold War, the perceived necessity of secrecy and security veiled the sites from nearly any oversight. For all intents and purposes, the agency regulated itself. Not surprisingly, the resulting ecological degradation is impressive to say the least. In 1989, then Energy Secretary James Watkins appointed Leo P. Duffy to head DOE's restoration effort. Duffy became the first assistant secretary for environmental restoration and management. Under his leadership, DOE established a basic strategy and its Environmental Restoration Management Contractor (ERMC) approach for handling cleanups, but our following discussion of the Hanford Nuclear Weapon Plant in Washington state demonstrates how far DOE has yet to go.[36]

In 1989, a tri-party agreement was signed between DOE, EPA, and Washington's State Department of Ecology for execution of the cleanup of Hanford. At the core of Hanford's waste problem were 28 double-shelled tanks storing high-level radioactive/chemical wastes and 149 single-shelled tanks storing low-level wastes. In all,

---

[34]EBI. "Site Remediation Markets", Environmental Business Journal, August 1994, p. 5.
[35]Powers, M. and Rubin, D. "Cleanup Contract Protest Upheld", ENR, October 25, 1993, p. 9.
[36]The following details of the Hanford case were constructed from several articles appearing in ENR "DOE Rethinks Strategy to Clean Up Hanford", April 19, 1993; "Pact Reached on Hanford Cleanup", October 11, 1993; and "Cleanup Contract Protest Upheld", October 25, 1993.

61 million gallons of waste are stored at Hanford. The initial agreement called for the construction of a $1.2 billion vitrification plant to handle the high-level wastes. In the spring of 1993, DOE balked on the original agreement. With the start date for the construction of the vitrification plant just weeks away, DOE gained a six month reprieve from the other tri-party members. Fluor Daniel, Inc., the plant's designer, and United Engineers & Constructors Inc., the plant's builder, were left in limbo. DOE Hanford Manager John Wagoner felt it would be imprudent to begin construction of the vitrification plant since larger problems were arising in the handling and treatment of the wastes already on site. Foremost among Wagoner's concerns was the choice of unproven technologies for the treatment of the high-level wastes, a concern echoed by the US General Accounting Office (GAO). At the time, Wagoner sought to demonstrate pretreatment technologies and delay full blown cleanup until the demonstrations proved successful.

In the fall of 1993, DOE signed a new pact with the tri-party members, resolving the cleanup delays at Hanford. Attention shifted to the low-level wastes, and construction of a $500 million dollar vitrification plant for handling them was scheduled to begin in 1997. Meanwhile, the start of construction of the high-level waste vitrification plant was delayed until 2002. Additionally, plans began for the construction of a multi-purpose storage complex in Nevada for housing the vitrified glass logs. Originally, the low-level liquid wastes were to be blended with cement, fly ash, and clay creating a grout for storage in buried vaults 34 feet below ground. Construction of plants for processing the low-level wastes and vaults for storage were already underway at a $200 million pricetag. Public opposition to this proposed plan, however, forced the tri-party to find an alternative solution, thus, the low-level vitrification proposal.

As if this were not enough, GAO upheld a protest filed by Parsons Environmental Services Inc. against the award of the Hanford ERMC to a team lead by Bechtel Group, Inc. Following a nine month review, GAO questioned DOE's evaluation of "the most probable cost to the government" for management of costs and fees. GAO's lead attorney in the evaluation said that DOE's cost evaluation was defective. Many question the agency's ability to procure ecological services. Further, the precedent established by this protest could forewarn of prevalent bid protests. This is particularly alarming to cleanup contractors since ERMC bids can cost up to $2 million.

As the Hanford case attests, DOE appears to be a rather unsophisticated client. Beyond the procurement difficulties cited, their changes in scope and intent not only wasted money but also changed several contractors' short-term expectations of income. Moving the date of construction for the $1.2 billion vitrification plant from 1994 to 2002

is quite a substantial change. While just compensation for the contractors is certainly probable, this change no less alters their corporate strategy and project portfolio. From this evidence, a DOE client relationship may prove quite risky.

3.2.3.2 DOE's Present and Future

Leo Duffy instituted the ERMC and put outside contractors in charge of cleanup and construction. This was quite a change from the traditional M&O strategy that granted nearly total control of a DOE site to the M&O contractor. Duffy stated that he intended to integrate people "who know the cleanup business, who know the regulations and the regulators. That's their career."[37] While the Hanford ERMC is under scrutiny, an ERMC at Fernald, OH is proceeding as planned. In August of 1992, DOE awarded the contract (the first ERMC) to the Fernald Environmental Restoration Corporation (FERMCO) to cleanup a former uranium processing facility. FERMCO is a wholly-owned subsidiary of Fluor Daniel, Inc., and three partners join their project team: Jacobs Engineering Group, Halliburton NUS Environmental Services, and Nuclear Fuel Services. Members of the Fernald Environmental Restoration Management Team describe their relationship with DOE:

> *Under the ERMC concept, the contractor uses its own funds to manage all activities which support the cleanup effort and bills the government for reimbursement of these costs. The contractor earns its profit or fee based on its performance in meeting specific requirements or milestones set by the DOE. While an ERMC has considerably more authority to manage various elements of the cleanup operation, including subcontracting for specific services, the contractor also assumes liability for its work and must justify its expenses in order to receive reimbursement from the government.*

Such a description of the ERMC client-contractor relationship parallels the approaches adopted by the members of DOD in their contract arrangements. While the scope of work is more in line with USACE's TERCs, the cost-reimbursable, performance fee contract approach is common to each agency.

Thomas P. Grumbly took the DOE's restoration reigns from Duffy in 1993. The new administration indicates its intent to continue using the ERMC approach. Grumbly and new Energy Secretary Hazel O'Leary are altering, however, several other dimensions of the agency's environmental program. Essentially, their initiatives are focusing upon two

---

[37]Rubin, D. "Leo P. Duffy, Man of the Year", ENR, February 15, 1993, p. 35.

areas: contract management and risk management. Grumbly intends to shift contracting authority and oversight away from Washington to DOE field offices prompting a potential 1,000 employee increase in field offices. Many are concerned about the effects such a bureaucratic increase may have upon the speed of cleanups. Grumbly hopes to counter such concerns by holding site managers accountable for agreed upon cleanup milestones and providing contractors financial rewards for "real performance". Another contract management initiative under consideration is a move away from the traditional M&O strategy toward privatization. DOE wants to create performance based contracts that encourage contractors to build, own, and operate remediation facilities that "produce" a clean product that the agency would then buy back. Grumbly and company envision teams of prime contractors and subcontractors competing for the jobs. Under such an approach, DOE would shift regulatory oversight of its facilities to other agencies such as OSHA and the Nuclear Regulatory Commission. A pilot program incorporating such elements is underway at the Rocky Flats facility outside Denver, CO.[38]

Additionally, DOE has launched a $50 million program through mid-1995 to determine long-term health, safety, and ecological risks at each of its sites. Principle in this risk evaluation is the concept of land-use planning where future site use is considered rather than unrestricted use. Such an approach to risk management in cleanups is gaining popularity throughout the United States, but some evidence suggests that individual states will resist it. David Humphrey, deputy director of Idaho's Department of Health & Welfare, comments, "zero risk is the only acceptable risk." Only time will tell whether or not states and the public will grant their approval.

Clearly, DOE is stepping in the right direction. Its developing contract and risk management philosophy is consistent with those gaining prominence throughout the country, but its apparent lack of procurement expertise keeps it an unreliable client. Longstanding operations and procedures require dismantling, and as Yates et al. contest, its culture needs adjustment. Remediation requires flexibility while DOE's past operations reinforce rigidity. Until such changes occur, DOE cleanups will continue to trudge along, and it shall remain a giant asleep.

---

[38]Details were constructed from several articles appearing in ENR "DOE Cleanup Is Scrutinized" and "Leo P. Duffy: Man of the Year", February 15, 1993; "O' Leary Sics OSHA on DOE", May 17, 1993; "DOE to Clean Up Its Act", June 7, 1993; "DOE Sets a Course to Speed Cleanup of Its Weapon Sites", October 11, 1993; "Cleanup Reshaping Rocky Flats", May 16, 1994; and "DOE Cleanup Contracts Rattle", September 5, 1994.

3.3 State Cleanups

In the spring of 1993, a federal appeals court in Denver, CO ruled that Colorado's hazardous waste law took precedence over EPA's rules for governing the cleanup of federal Superfund sites. While the ruling prompted some controversy, it was one of many trends that signal greater state control in future hazardous waste cleanups. Collectively, states identified 50,000 contaminated sites of which 28,192 may require cleanup and 6,169 are priorities.[39] Additionally, many states require ecological assessments and cleanups during property transactions, so ecological considerations are becoming integral parts of future real estate development. Some states have proven more proactive than others in their cleanup programs. Our following discussions will highlight efforts in California, Florida, Michigan, and New Jersey for administering cleanups.

3.3.1 California

California is home of some of the toughest air quality laws in the country. The state, however, has taken a rather proactive position in waste cleanups. Its CA Environmental Protection Agency (CEPA) worked in conjunction with the Environmental Technology Advisory Council (ETAC) in creating a plan designed to streamline site cleanups.[40] ETAC includes firms such as Dames & Moore and the Bechtel Group, Inc. Principle components of the ten-year plan are permitting efficiently, developing cleanup standards, and providing incentives for innovative technology use. The plan would create five additional "one-stop-shops" throughout the state for ecological permitting like the first instituted in Los Angeles in July of 1993. Further, the plan calls for standardizing test protocols and analytical procedures in cleanups. Such standards would lessen the uncertainty involved in site characterizations and increase client confidence in the methods employed. Finally, the plan provides economic incentives for firms that reduce pollution beyond regulated limits. Those who do can sell pollution credits to others. Members hope this incentive will spur the use of innovative ecological technologies.

---

[39]Moavenzadeh, F. Global Construction and the Environment: Strategies & Opportunities. New York: John Wiley & Sons, 1994, p. 145.

[40]Details from: Anonymous. "California Eases Rules to Spur Growth of Jobs", ENR, November 22, 1993.

3.3.2 Florida

Florida is home to 53 active Superfund sites with estimated per site cleanup costs ranging from $500,000 to $26 million. Since the mid-1980s, Florida's Department of Environmental Restoration (FDER) has managed its own Superfund remediation program.[41] Initially, the state contracted separately for remedial characterization/design and remedial construction services. FDER experienced rather slow cleanup progress as did similar approaches. In fact, an audit by the state's Auditor General (AG) found that in 1992 cleanup had not begun at 66 of 75 designated state sites. The AG attributed this discrepancy to the lack of established deadlines for cleanup plans and limits for revisions of those plans. Charles Lester, state AG, comments: "It is possible for a responsible party to intentionally slow down the model orders process by continually submitting for review plans or reports that do not meet department specifications". In partial response, the state has adopted a turnkey contracting approach on a small scale where a single firm is awarded the responsibility of handling all aspects of the project. FDER cites enhanced project efficiency, cost-effectiveness, quality, and innovation as the primary benefits of this approach. In addition, the traditional client-contractor relationship evolves into a cooperative one where engineers, contractors, and the state work in unison to achieve an efficient cleanup.

3.3.3 Michigan

In 1990, Chrysler Corporation proposed building a $1 billion Jeep plant in Detroit.[42] The chosen site was contaminated with gasoline and heavy metals. Rather than opt for a new site, Chrysler and the state compromised on a $25 million cleanup project to contain and stabilize the contaminants rather than completely remove them. Thus, the new plant opened in 1992 employing 3,100 people. This situation prompted Michigan to adopt new rules about site cleanups particularly in urban areas where old industrial properties are common. The results of the previous laws and regulations were threefold: 1) regulatory compliance costs were driving employers away from urban areas, 2) this flight resulted in industrial development in uncontaminated areas, and 3) suburban development increased urban sprawl and resulted in more air pollution as employees must drive to work. As

---

[41]Details of FDER's programs were constructed from ENR articles "Florida's Innovative Procurement System Speeds Cleanups", April 12, 1993 and "Florida Cleanups Limp Along", February 21, 1994.
[42]Details from: Schneider, K. "Rules Easing for Urban Toxic Cleanups", National Desk, September 20, 1993.

mentioned, Michigan moved to counter this trend by changing its cleanup provisions. If minimal site contamination is present and it does not threaten drinking water or air quality, cleanup merely entails sealing the contaminants in soil or clay. In addition, the state Attorney General's office will refrain from suing buyers of old industrial properties for the cost of cleanup. Many worry such provisions weaken the state's ecological laws too much. Further, the state has been slow to implement the new approach.

3.3.4 New Jersey

New Jersey's Environmental Cleanup Responsibility Act of 1983 (ECRA) was one of the most stringent and oft-criticized state ecological laws in the country.[43] Designed to prevent the sale, transfer, or abandonment of contaminated real estate, its bureaucracy dramatically hindered the cleanup and further development of contaminated sites. In June of 1993, the state passed the Industrial Site Recovery Act (ISRA) that aimed to balance economic renewal and environmental protection. Governor Jim Florio stated: *We'll attract private-sector investment where it's needed most, recover unused land for more productive uses and, above all, untie the hands of industry to create new jobs.* Response from industry is mixed. Frank Reick, president of Fluoramics Inc. a company which specializes in high-tech lubricants, comments: *I absolutely refuse to set up new operations in New Jersey until I see real change. ISRA has done nothing but institutionalize ECRA. It has made sure the bureaucracy is tenured.* Others view ISRA with optimism since the law creates real possibilities of recycling old industrial sites in New Jersey. Principle components of the law are: 1) a one-in-million cancer risk cleanup standard, 2) allowances for sealing contaminants rather than removal as appropriate, 3) remediation decisions based upon future land use, and 4) a $50 million trust to assist "innocent" property owners in cleanups.

3.4 Private Cleanups

Private cleanups take three forms: voluntary, Superfund PRP, or a RCRA corrective action. To some, the use of the word "voluntary" to describe private cleanups is a fallacy, but I prefer to characterize a proactive effort by a private firm or party as voluntary. Indeed, regulatory influence is present, but a voluntary effort is initiated by the responsible

[43]Details from : Molnar, L. "Changes in an Environmental Law Draw Mixed Reviews from Business", The New York Times, Oct 24, 1993; and Garbarine, R. "In the Region: New Jersey; Making Industrial Site Cleanups Easier", The New York Times, July 11, 1993.

party and not the regulator. In 1993, 44% of all client revenues were generated by these three cleanup categories (figure 2), but the number of new private projects were minimal. Some blame this upon a lingering sluggish economy, and most market experts do not predict a dramatic increase in private work in the near future.

Nonetheless, Superfund cleanup privatization offers numerous advantages as the experience of C&P Telephone Company of Virginia attests.[44] The EPA identified C&P as one of many PRPs at the C&R Battery Company Superfund site near Richmond, VA. Following the EPA's record of decision (ROD), C&P privatized the site with the engineering and counsel assistance of Geraghty & Miller, Inc. and McSweeney, Burtch & Crump P.C. respectively. The ROD required the excavation, on-site treatment and off-site disposal of 38,000 cubic yards of lead-contaminated soil at an estimated cost of $16 million. The C&P group evaluated the plan and received EPA approval to perform additional site screening that allowed greater accuracy in locating soil contaminants. Further, they rescheduled construction activities for greater efficiency. As a result of this value engineering analysis, the group cut the expected project cost by $10 million. C&P indicates that timing and flexibility are the key success factors for cleanup privatization. The sooner the project is privatized the greater the opportunity for cost savings, and C&P suggests continually considering all alternatives throughout a project's duration. Certainly, this example demonstrates how privatization can control Superfund cleanup costs.

On the voluntary front, the Hazardous Waste Action Coalition (HWAC) advocates a voluntary cleanup program administered by the states for cleanups governed under RCRA.[45] Under their proposal, firms would submit cleanup plan proposals to the appropriate state agency. States would then notify EPA, and EPA would either provide input or oversight for the cleanup, or allow the state to control it. Firms would compensate the state for the reasonable cost of evaluating the proposals. Before any of this could happen, the state's cleanup program would require EPA approval. OHM Remediation Corporation created a similar plan in a legislative proposal entitled the Voluntary Environmental Response Act. Additionally, a non-profit group out of California, the Institute of Environmental Solutions, Inc., plans to create a $100 million lending pool to finance site remediation, technology commercialization, and regulatory oversight in hopes of speeding redevelopment of contaminated sites.[46]

---

[44]Details of the case were constructed from: Moore, J., Keller, J., Ziglar, R. and Hancock, F. "Privatization Can Lower Cost of Superfund Cleanups", ENR, Special section on environmental engineering, April 12, 1993.

[45]Details from: Patterson, K., Power, J. and Kiely, C. "Owners Seek Incentives for Voluntary Cleanups", ENR, Special section on environmental engineering, November 22, 1993.

[46]Anonymous. "Fund Pushed to Speed Reuse of Toxic Sites", ENR, November 15, 1993.

Obviously, privatization can offer advantages particularly during Superfund cleanups, but I expect that C&P Telephone's example is the exception rather than the rule. EPA can prove rather inflexible in altering its decisions, but increasingly, they are at least considering alternatives. As C&P recommended, early involvement heightens the possibility of influencing them, but both the Superfund and RCRA process are inherently inefficient. Initiatives are underway to alter them, but until the processes are "fixed", I imagine private-lead cleanups will remain slow.

3.5 Summary

A variety of firms chose to diversify into remediation in the mid-80s. Members of the waste management, construction, environmental services, and defense industries opportunistically entered the market expecting substantial rewards. Today, fierce competition and an oppressive regulatory system have dampened the market's promise. Future success depends on a realistic evaluation of developing trends today. What lies ahead? In this chapter, our analysis of remediation markets demonstrates several trends:

1. Continued growth of turnkey contracts and projects evidenced by USACE's TERCs and DOE's ERMCs.
2. Continued contract evolution from cost plus performance fee back toward fixed price contracts as remediation clients and contractors gain experience.
3. Domination of the public sector market by DOD with experienced contract and project management capabilities.
4. Increasing importance of value in remediation services as clients become more discriminating and experienced; services will need to offer elements beyond low price.
5. Increasing importance of the consolidation or the teaming of services to receive remediation work given the magnitude of turnkey projects.
6. Lessening importance of design services as contractors gain experience in implementing solutions based only upon site characterization.
7. More emphasis upon site containment rather than cleanup as legislators and the public continue to question the economic and public health justification of extensive cleanup efforts.

Understanding and preparing for these trends promise success in the future.

Chapter 4
APPROACHES TO RISK MANAGEMENT

Chance favors the trained mind.

- Louis Pasteur

4.1 Risk and Remediation

Tenuous liabilities have forced the remediation industry to adopt acute approaches to risk management, not only to protect their organizational health but also to protect the physical health of their workforce and the public. Understanding the risks involved in remediation is intuitively necessary for conducting remedial activities. Certainly, engineers and contractors are not unaccustomed to substantial risks. In the construction industry for example, traditional design and construction organizations regularly assume them in the services they offer. Designers undertake the risk that they can translate their clients' needs and desires into an integral plan with structural, mechanical and electrical integrity. Contractors shoulder the risk that they can transform the designed plan into physical reality. As elements of the industry have entered the remediation market, they have found risks in this segment similar to those in traditional construction, but they are somewhat different and certainly magnified. Risks in remediation can take on latent and disastrous qualities, especially in the areas of finance and liability. Their complexity is amplified by an uncertain and disparate regulatory environment. Federal, state and municipal requirements differ dramatically across the nation. Further, public opinions of the risks posed by hazardous wastes to human health and the ecology are nearly as dissimilar. *Seemingly*, risks in remediation reside within an intricate environment. In this chapter, I briefly characterize remediation risks, present case study results of strategic risk management approaches, and recommend improvements to current risk mitigation methods.

4.2 Risk Characterization

I classify the risks in remediation into two categories: ***business risks*** or ***physical risks***. Business risks are those consequences that result in financial loss or damage to a firm's reputation. They can dramatically influence an organization's profitability or survival. Business risks are generally decision-related such as client, partner, or project selection, resource allocations, or investments. An example business risk was IT's decision to accept the contract offered by Monsanto at the MOTCO Superfund site

discussed in chapter two. Business risks can also include implications of improper regulatory compliance or inefficient project management. Physical risks are generally those resulting from a firm's participation in a specific project. These might include typical construction site risks such as worker health and safety; public health risks such as possible injuries to the surrounding populace by accidental releases of hazardous materials; or ecological risks such as further damage to the natural surroundings from hazardous spills or releases. Obviously, this is not an exhaustive discussion of remediation risks. I intend it only to introduce the sort of risks involved.

4.3 Strategic Risk Management

Through case studies of several US remediation contractors, I discovered alternative approaches to managing risks in remediation from a strategic perspective. Strategies generally employed one or more of the following approaches:[47]

avoidance - risk is extensive so approach attempts to elude it.

transfer - risk is shifted to a third party.

share - risk is equitably distributed between parties.

retention - risk is kept by the organization.

loss prevention - risk potential is mitigated through training or procedures.

I classify these as *macro approaches*. Within each approach are different techniques such as contract management or project management. I classify these as *micro techniques*. As a result of interviews and case studies, I identified ten primary techniques for mitigating risks:

organizational structure: structuring an organization to minimize risks to a parent or other functions/departments.

project review: analysis of potential projects to weigh the consequences of involvement and subsequently opting to reject the project or participate in it.

market niche: selecting market segments with higher/lower risks.

insurance: coverage by contract binding one party to indemnify another against loss in return for premiums paid.

bond: an insurance contract covering unforeseen losses during remediation projects.

relationships: selecting clients/partners based upon analysis of desirable characteristics that may minimize the potential for loss or litigation.

---

[47]Construction Industry Institute. Allocation of Insurance-related Risks and Costs on Construction Projects. November 1993, p. 22.

contract management: properly drawing and agreeing to terms and conditions that minimize risks.

project management: properly planning, coordinating, and integrating the participants and systems for a remediation project to minimize risks.

policies: corporate or business unit directives or guidelines that minimize risks.

culture: corporate or business unit artifacts, values, and assumptions that encourage proper risk management.

Figure 4 graphically represents strategic approaches and techniques.

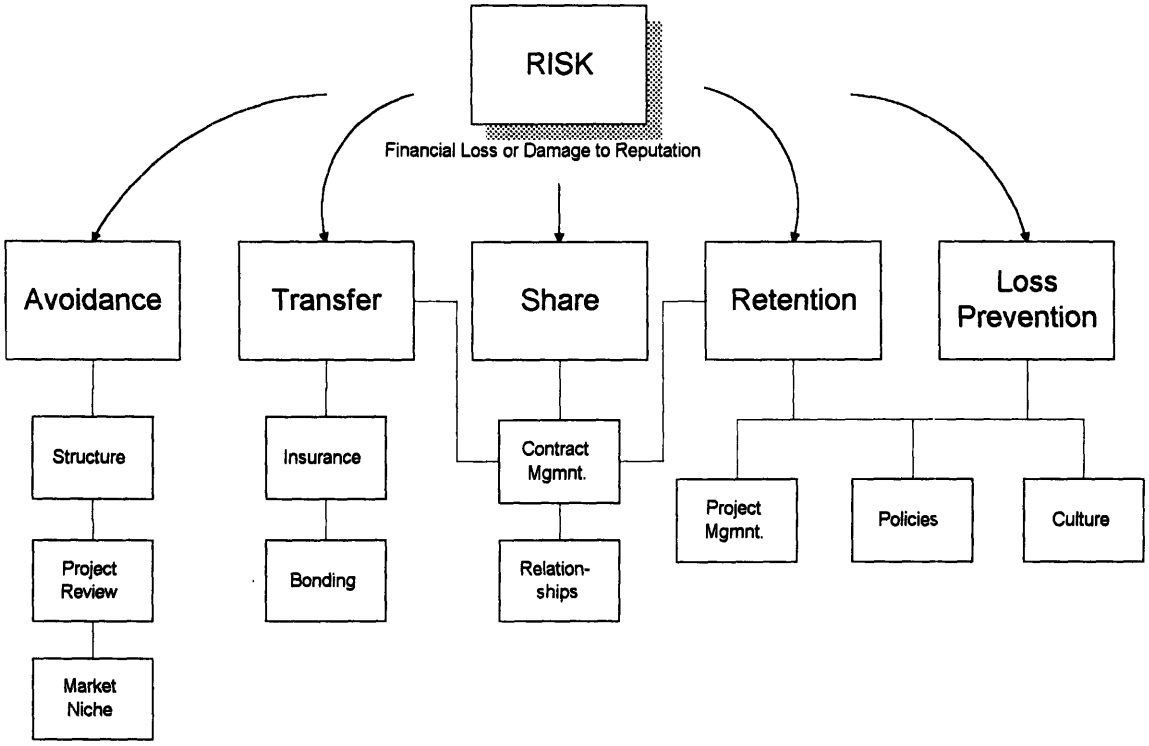

Figure 4. Macro Approaches and Micro Techniques to Strategic Risk Management

Some micro techniques transcend macro approaches. For example, a remediation contractor might transfer to or share certain risks with another party via contract terms and conditions, so contract management is a micro technique for both macro approaches of share and transfer. In the following discussions, we shall examine case examples of both macro approaches and micro techniques to strategic risk management.

4.4 Macro Approach Case Examples

This section shall examine approaches employed by the Perini Corporation and ICF Kaiser International, Inc. In each case, the corporate unit utilized a different risk management strategy as it developed its remediation business. As the examples will demonstrate, no risk management strategy was fully comprehensive, i.e. no strategy effectively employed each of the macro approaches. This suggests that trade-off decisions are probably necessary when considering approaches to risk management during remediation business development. Evidence from the research also suggests that the resulting strategies were a combination of the market situation at the time of decision and corporate decision-makers' risk preferences.

4.4.1 The Perini Corporation and Perland Environmental Technologies, Inc.

In 1988, Perini formed Perland Environmental Technologies, Inc. with two partners, Ashland Technologies Corporation, a subsidiary of Ashland Oil Company with remedial design experience, and Versar, an established participant in the remediation industry with site investigation experience. Ownership was split between Perini (47.5%), Ashland (42.5%), and Versar (10%). Perini opted to form Perland as a corporate subsidiary and use the concept of a corporate veil to protect itself from potential liabilities. Perini followed some guidelines, to the greatest extent possible, for keeping the veil intact resulting from court decisions where the validity of the corporate veil has been questioned:

1. The subsidiary does not operate at a deficit while the parent is showing a profit.
2. The creditors of the companies are not misled as to which company they are dealing with.
3. The subsidiary handles and makes decisions concerning salaries, employees, financing, contracts, bids, and purchasing.
4. The subsidiary has separate insurance.
5. The subsidiary has a separate office and telephone number.
6. The parent and subsidiary do not exchange assets, liabilities, equipment or people.[48]

Perini's strategy demonstrates the macro approaches of avoidance and share. Perini hoped to avoid the risks in remediation by structure in establishing Perland under the

[48]Information gathered from interviews with members of Perland. Perini followed guidelines suggested by an article appearing in the *Denver Law Journal* in 1978 titled "Piercing the Corporate Veil."

corporate veil principle, thereby protecting itself from potential liabilities. Further, it chose to distribute the financial risks with two partners by sharing ownership of the new company. Perini's strategy rates high in avoidance and sharing techniques, but low in transfer, retention, and loss prevention. Essentially, Perland became a company with no experience or credibility. Insurance and bond acquisition proved difficult. After a year of continual effort, Perland gained the trust of an established bonding company, but even today, the company still **thoroughly** evaluates each project before granting a bond. In addition, the company refuses to bond most projects in New York or Texas since legislation defining the liability trail is lacking. Interviews with members of Perland suggested that without Perini's reputation, Perland might never have established a sustainable relationship with a bonding company. Beyond the transfer discrepancies in the risk management strategy, Perini formed a company with little or no experience in retention or loss prevention techniques. True, a construction company has substantial experience in contract and project management, but the amplified health and safety risks were new ground for both Perland and Perini. Further, Perini lacked the technological and systems knowledge necessary for the industry. Perini acquired some skills for Perland in part through its ownership relationships, but still company policies and culture required creation.

Initially, Perini's strategy appeared strong for risk management. Over time, however, Perini bought out its partners since both proved hesitant to expose themselves or assist in bond acquisition. Today, Perland is a wholly-owned subsidiary of Perini, and the current parent-subsidiary relationship violates some of the corporate veil guidelines since Perland has recently moved into Perini's home office and it utilizes some of Perini's equipment and assets. In hindsight, Perini may have gained more through transfer, retention or loss prevention approaches as it created its remediation business. At the time, however, corporate decision-makers felt the situation mandated avoidance and sharing approaches to protect its assets and shareholders.

4.4.2 ICF Kaiser International, Inc.

Recently, ICF Kaiser planned to expand the breadth of its ecological services by providing remedial construction. It chose to purchase GeoCon, a Pittsburgh-based remediation contractor, and make it a part of its Environment and Energy Group. This strategy is nearly the polar opposite of the one enacted by Perini. Where Perini adopted an approach strong in avoidance and sharing, ICF Kaiser chose approaches weak in these areas, but strong in transfer, retention, and loss prevention. It gained an established firm

with existing policies, culture, and bond/insurance relationships. In addition, ICF Kaiser's own relationships and assets can be exploited as necessary since there is no need to maintain a corporate veil. Obviously, these assets, though, become vulnerable to possible liabilities. Perhaps, the explanation for the strategy taken by ICF Kaiser as opposed to Perini is provided by the maturation of the industry today as opposed to the late 1980s. Further, the predominance of large government contracts forced ICF Kaiser to "take aggressive action...[making] a strategic decision to invest additional resources in obtaining the skills needed to win large environmental projects."[49] Regardless of the explanation, ICF Kaiser adopted a more aggressive approach to risk management and remediation business development.

4.5 Micro Technique Case Examples

Complementing the macro approaches are micro techniques. In the following discussions, we shall examine Perland's project management, Clean Harbors' culture and policies, and GZA Remediation's contract management. Certainly, these examples are not "recipes", but they do represent some interesting techniques for risk mitigation.

4.5.1 Project Management at Perland

Perland follows a rather thorough methodology for management on each of its projects, the *Expedited Remedial Action Methodology* (ERAM). The goal of ERAM is to complete remedial actions as quickly as possible with a minimum amount of engineering expenditures. Figure 5 schematically depicts ERAM. Initially, Perland performs a site survey and collects all appropriate federal, state, and local regulatory requirements. Prior to the site survey, the firm reviews relevant site history documents and identifies potential conflicts of interest. The purpose of step one is to review unique features of a site and to identify project activities or features that might impact project cost, schedule, quality or safety. Following step one completion, Perland prepares a preliminary construction cost estimate as soon as possible to discover major unknowns and cost drivers. Alternatives to reduce uncertainties and value engineering opportunities are examined. Concurrently, decision logic trees are created to identify appropriate cleanliness criteria, and field sampling matrices are prepared to summarize the chemical and physical sample requirements of the project. Further, opportunities for inclusion of small and small

[49]ICF Kaiser International, Inc. Annual Report, 1994, Fairfax, VA.

disadvantaged businesses as subcontractors for the project are investigated. At the

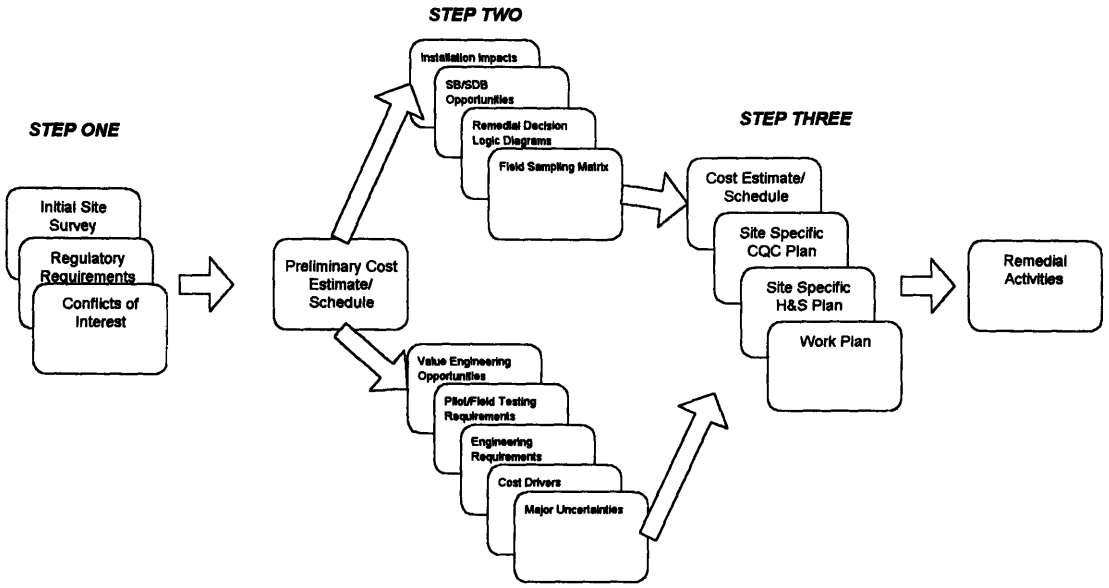

Figure 5. ERAM

completion of step two, Perland prepares a detailed work plan that includes, at a minimum, a site health and safety plan, a field sampling plan, a quality assurance plan, and a contractor quality control plan. If necessary, it will also include a community relations plan. Perland intends to complete steps one through three in less than thirty days.

ERAM's primary objective is to focus the project team on all the critical issues of an assignment prior to expenditure initiation. Perland hopes to incorporate the knowledge of engineers, scientists, and constructors to provide expeditious and effective completion of complex remedial work. Perland has successfully implemented this approach on multiple projects such as a pump-and-treat action for a DOD installation in the Atlantic Coastal Plain of New Jersey to minimize plume migration.

4.5.2 Clean Harbors' Culture and Policies

Almost immediately, I sensed how important the health and safety of its workforce was to Clean Harbors Environmental Services during an interview with a senior manager. My initial impression proved true. In fact, the company maintains health and safety records on a central database and prepares quarterly reports for evaluation where managers are measured against quantitative performance standards. Managers are *expected* to achieve them. Of its six corporate priorities, health and safety tops the list. Yet, the prevailing values and operating systems sometimes prove detrimental. While Clean Harbors markets its health and safety reputation and program as a plus, its

comprehensive nature has proven a liability on occasion. Since minuscule incidents or violations of their program are reported regularly, their incident rate may give the impression of careless or inefficient operations. Managers worry that potential clients fail to understand the extent of their program, so they incorrectly assume competitors with lower incident rates are better. Recently, Clean Harbors' Operations Committee met to discuss this discrepancy. They concluded that better marketing and client communication was necessary rather than altering their health and safety program's standards or procedures. Indeed, health and safety is important to the company, and it is one of its fundamental values.

Beyond this program, Clean Harbors evaluates all projects during proposal development for discrepancies such as inappropriate contract terms and conditions, possible indemnification arrangements, and potential liability penalties. During actual contract execution, Corporate Legal reviews all contract documents before final agreement. The firm is also making use of Massachusetts LSP licensing program to speed remedial activities. Under this program, a license is given to qualifying individual engineers which grants them certain authority for making certain ecological decisions without acquiring state approval; only a report must be given. This program, though it enhances cleanup efficiency, places greater risk upon the individual and the company for liability. To mitigate this risk, Clean Harbors conducts peer reviews of all such decisions before execution. Further, Clean Harbors conducts monthly training to inform all levels about changing ecological regulations and new operating procedures or requirements.

4.5.3 GZA Remediation's Contract Management

As one of its primary tenets for risk management, GZA hopes to establish clear communications with its clients, so it instituted a policy that all work be "conducted in accordance with a signed contract that must include a specific statement of work and detailed terms and conditions."[50] While some of their mandatory terms may seem obvious to GZA staff, they may not seem so to clients. For example, GZA demands the right of entry particularly on property not owned by the client. Contracts must include mention that subsurface exploration may disturb client properties, if appropriate. Further, clients must disclose in writing any knowledge they have of on-site hazards. Another important dimension of their contract management technique is communication of standards of care to the client. GZA makes it a point to demonstrate to the client that their methods or

[50]Balco, J. "Managing Risk in an Engineering and Environmental Company", Risk Management, June 1993, p. 57.

operations are in compliance with current regulations or standards of practice appropriate for the industry. Future standards are beyond their capacity to prepare for or predict.

In addition to fairly strict contracting policies, GZA hopes to handle all claims internally by identifying potential issues quickly and resolving them before they become problems requiring legal action. Normally, individuals tend to hide discrepancies or place blame elsewhere. To counter this tendency, GZA "consciously strives to establish an environment where recognizing, reporting, and taking reasonable action on problems is considered a positive achievement."[51] Essentially, GZA hopes to establish a proactive rather than a reactive environment.

4.6 A Risk Management Hierarchy

From my analysis of the risk management approaches of US remediation firms, I suggest, at this juncture in the industry's evolution, that traditional approaches to risk management are quite adequate. Remediation firms have gained the necessary experience to make prudent business and project related decisions, and the bonding and insurance industry has gained enough confidence in the market to grant indemnification policies. As a result of my interviews with several senior members of remediation firms, I recommend approaches focused upon retention and loss prevention rather than avoidance, transfer or share. Relying upon corporate structure or insurance policies to protect a company's assets is a tenuous strategy. Accordingly, I provide the following risk management hierarchy as a guide for corporate strategy and decision-making as business plans and operational programs are developed and implemented:

Approaches	*Techniques*
1. Retention/Loss Prevention	1. Contract Management
2. Share	2. Project Management
3. Transfer	3. Health & Safety Policy
4. Avoidance	4. Relationships
	5. Insurance/Bonding
	6. Structure

While traditional risk management approaches were generally adequate, I discovered an area where remediation firms seemed unprepared and almost hesitant for involvement: risk communication to the public. Certainly, this is a difficult task, and the EPA or the client has normally assumed this role in the past. Unfortunately, their efforts often are

[51] Ibid., p. 58.

inadequate. Recall our discussion of the New Bedford Superfund Site where a public organization of three stopped the project by opposing the incineration effort. The contractor lost substantial expected revenue and risks much as the dredged sludge sits in a temporary containment facility. With situations such as these, I was surprised by one senior member of a firm who commented that they were not in the business of making decisions in the public's interest; they served the client's interests. While I am sure the firm at the source of this statement is not socially negligent, I find this quite a dangerous attitude. Beyond a firm's social responsibility, a prevailing attitude of this sort can have dramatic business consequences as the New Bedford example attests. Increasing public involvement in remediation projects is likely. Remediation firms must be prepared to involve them. By understanding societal risk perceptions, an organization might better understand its role in society. Better yet, it might better manage risk.

4.7 Risk Perceptions

Dissimilar societal views of the risks posed by hazardous wastes are commonplace. We might find the source of this dissimilarity in human cognitive processes. The majority of citizens rely on intuitive judgments to evaluate hazards; unfortunately, their experience with hazards tends to come from the media, which just happens to pay significant attention to accidents and mishaps around the world.[52] The result is a populace that views the world as a riskier place today than in the past. Perhaps, a comment from A. Wildavsky best demonstrates the phenomenon:

> *How extraordinary! The richest, longest lived, best protected, most resourceful civilization, with the highest degree of insight into its own technology, is on its way to becoming the most frightened.*
>
> *Is it our environment or ourselves that have changed? Would people like us have had this sort of concern in the past? . . . Today, there are risks from numerous small dams far exceeding those from nuclear reactors. Why is the one feared and not the other? Is it just that we are used to the old or are some of us looking differently at essentially the same sorts of experience?*

This thought vividly demonstrates the seeming hysteria that engulfs society today, but are society's positions unfounded? In this regard, the comment, more importantly, indicates the need for "experts" to understand and lend credibility to society's--the lay person's--

[52]Slovic, P. "Perception of Risk", Science, April 17, 1987, p. 280.

position. Without this, society may not accept worthy endeavors regardless of how much scientific proof exists about the innocuous effects of it.

4.7.1 Psychometric Research

Researchers began in the late 1960s to employ psychometric techniques, psycho-physical scaling and multivariate analysis techniques to produce quantitative representations or "cognitive maps", to understand risk attitudes and perceptions. Starr lead such a pioneering effort in 1969. One result of this research is the insight that risk means different things to different people. For example, expert judgments of risk correlate highly with technical estimates of annual fatalities, while lay judgments relate more closely with other risk characteristics, i.e. potential for catastrophe. Further, such research indicates that lay people find current levels of risk substantially unacceptable. Slovic suggests that this gap between perceived and desired risk levels suggests that people are not satisfied with the way that market and other regulatory mechanisms have balanced risks and benefits.

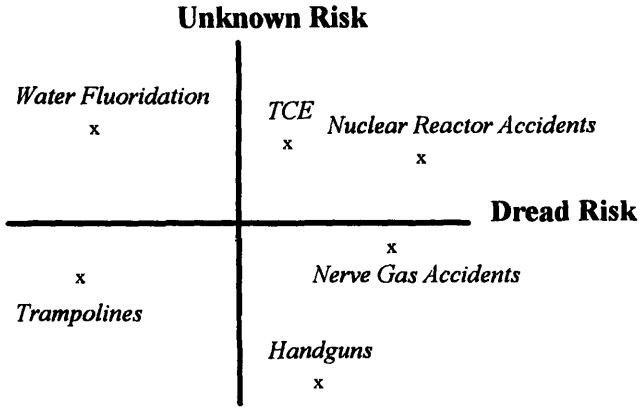

Figure 6. Factor Space Analysis[53]

Since initial research indicated that lay people correlate certain hazards with risk characteristics or factors, researchers employed factor analysis techniques to understand these relationships. Slovic's research published in 1985 created a factor space such as that shown in figure 6, where individuals placed certain hazards within it. "Dread risk" was defined at its high end (right) by perceived lack of control, dread, catastrophic potential, fatal consequences, and inequitable distribution of risks and benefits. "Unknown risk" was defined at its high end (top) by hazards judged to be unobservable, unknown, new, and delayed in their manifestation of harm. Significant conclusions from this research are twofold: first, lay people place the most significance upon "dread risk"; the higher a hazard rates upon this dimension the more individuals want to see the risk reduced and the hazard regulated or controlled; second, expert perceptions of risk are not

[53]This figure is adapted from the article by Paul Slovic. It is only intended to demonstrate the factor space analysis technique and provide the general positions of different hazards that such research has determined.

related to the factors; instead, they remain relative to expected annual fatalities. Once again, this demonstrates the disparity between expert and lay opinions.

Finally, Slovic's research has demonstrated that "the seriousness and higher order impacts of an unfortunate event are determined, in part, by what that event signals or portends. He describes this as an event's "signal potential". Further, an event's potential social impact is strongly related to its position within the factor space. For example, a familiar and well-understood system influences society in a relatively small manner. While the recent USAir accident in Pittsburgh is certainly tragic and investigations into its cause are necessary, air travel will experience little if any decline even though the accident was quite catastrophic. This accident is unlikely to become a "harbinger of doom", warning society that future air travel is likely to produce similar or more tragic results. Conversely, few accident have had the signal potential that the chemical manufacturing accident in Bhopal, India did. The following excerpt from an editorial on Bhopal in *New Yorker* magazine in 1985 provides this insight:

> *What truly grips us in these accounts is not so much the numbers as the spectacle of suddenly vanishing competence, of men utterly routed by technology, of fail-safe systems failing with a logic as inexorable as it was once--indeed, right up until that very moment--unforeseeable. And the spectacle haunts us because it seems to carry allegorical import, like the whispery omen of a hovering future.*

As a result, the chemical industry has scrambled in recent years to re-establish itself within society. Slovic found that hazards from the upper right quadrant of his factor space displayed the greatest signal potential. Among those hazards are PCB's, trichloroethylene, cadmium usage, and radioactive waste. Accordingly, risk managers should be particularly attuned to the signal potential of such hazards.

Indeed, psychometric research has disclosed the difference between expert and lay judgments of risk. While experts have generally had the inclination to characterize the public's inability to cope with seemingly minimal risks as ignorance, such is not the case. Individuals tend to adopt fuller conceptualizations of the risks a hazard presents while experts lean toward narrower definitions.[54] This discrepancy will normally result in conflict between the two groups as each struggles to impart its position upon the other. Risk managers and communicators must realize this. Without it, their efforts to involve the public will probably result in adversity.

---

[54]Ibid., p. 285.

4.7.2 Trust

Aside from the disparity between expert and lay perceptions of risk, the trust society places in the individuals or the institutions responsible for risk management has become significant. The controversies surrounding nuclear energy have served as a "laboratory" for analyzing methods and efforts at risk management and communication. Probably more than $1 billion has been spent to conduct extensive studies to assess the human health consequences of radiation exposure and to develop probabilistic risk analyses for nuclear reactors, dams, and other engineered facilities to assist in risk communication. Still, public opposition to nuclear facilities is tremendous. Slovic argues:

> *Public fears and opposition to nuclear-waste disposal plans can be seen as a "crisis in confidence," a profound breakdown of trust in the scientific, governmental, and industrial managers of nuclear technologies . . . The limited effectiveness of risk-communication efforts can be attributed to the lack of trust. If you trust the risk manager, communication is relatively easy. If trust is lacking, no form or process of communication will be satisfactory.*

Bella, Mosher and Calvo also discovered the drastic erosion of trust between society and the government and the nuclear industry. Now, this distrust nearly bars any meaningful communication about risks between them.

Trust itself is quite delicate. Nearly everyone has experienced the difficulties with developing it in their personal relationships. Creating it is an arduous process; destroying it a fleeting one. This asymmetry has been studied often by psychologists. In a study where people rated 150 descriptive traits (gentle, adventurous) relative to the number of behavioral instances necessary to either create or destroy them, Rothbart and Park found that favorable traits were judged as hard to attain and easy to lose, whereas unfavorable traits were judged as easy to acquire and difficult to relinquish. Trustworthiness stood out as the most difficult trait to acquire but the simplest one to surrender. Slovic further argues that this asymmetry is tilted toward distrust because: 1) negative (trust-destroying) events are more visible or noticeable than positive (trust-building) events; 2) when events do come to one's attention, negative (trust-destroying) events carry much greater weight than positive events; 3) sources of bad (trust-destroying) news tend to be seen as more credible than sources of good news; and 4) distrust, once initiated, tends to reinforce and perpetuate distrust. He argues that the first circumstance is true because negative events are defined incidents such as accidents, lies or other mismanagement, but positive events are often indistinct. For example, how many positive events are represented by the safe

operation of a Boeing 737? The answer is rather nebulous; more importantly, it has little consequence upon our attitudes toward air travel.

Slovic supports his second postulate with research into the relationship between a large nuclear power plant and a surrounding community. He surveyed respondents about the effects that 45 hypothetical news events pertaining to the management of the plant would have upon trust. Some news events were trust increasing: *the county medical examiner reports that the health of people living near the plant is better than the average for the region*; some were trust decreasing: *the county medical examiner reports that the health of people living near the plant is worse than the average for the region.* Not surprisingly, negative events were seen as far more likely to have a powerful effect on trust than were positive events. On a scale of 1 (very small impact on trust) to 7 (very powerful impact on trust), 50% of the respondents rated the negative event described above as either a 6 or 7. Only 18.3% of them rated the positive event described above as either a 6 or 7. Slovic argues one reason for the greater impact of trust-destroying events is that the "importance of an event is at least in part related to its frequency (or rarity). An accident in a nuclear plant is more informative with regard to risk, than is a day without an accident." In this regard, low-probability/high-consequence events with negative implications will increase perceptions of risk to a greater extent than positive events will decrease them.[55]

Research by Efron supports his third axiom. In examining the responses of government regulators, Efron found that animal tests that result in negative consequences are considered credible evidence of risk to humans while tests that produce positive consequences have little significance. While the validity of animal studies are continually debated, the so-called "experts" place value upon negative results, whereas they discriminate against positive ones. Finally, Slovic supports his fourth postulate with two arguments. First, distrust tends to inhibit the kinds of personal contacts and experiences that are necessary to overcome distrust. Naturally, if one is skeptical of another, he tends to avoid association. Second, initial trust or distrust colors our interpretation of events, thus reinforcing our prior beliefs. Consider for yourself a personal example where your trust or distrust of an individual was steadfast. How did you respond to a subsequent negative event involving that person? If you trusted the person, you probably concluded the event was an honest mistake or the person did everything possible to preclude the event from happening. If you distrusted the person, the converse is probably true.

---

[55]Slovic, P. "Perceived Risk, Trust, and Democracy", Risk Analysis, June 1993, p. 678.

Clearly, trust becomes an important element of risk management and communication. Evidence from the nuclear energy debates indicts its absence as a primary barrier to convincing the public of the greater benefits than costs of nuclear power. Intuitively, we know trust is fragile, and the efforts for its creation are far greater than the incidents for its destruction. Further, humans are almost instinctively more skeptical than they are credible. Human behavior also tends to reinforce this skepticism. The nature of trust places organizations involved in risky endeavors at an extreme disadvantage, and they must remain vigilant to its importance and potential consequences.

4.7.3 Democracy in the U.S.

To this point, our discussion of risk perceptions has concentrated upon psychological perspectives. Slovic contributes a final thought to this discussion in the following excerpt:

> *Conflicts and controversies surrounding risk management are not due to public irrationality or ignorance but, instead, can be seen as expected side effects of these psychological tendencies, interacting with our remarkable form of participatory democratic government, and amplified by certain powerful technological and social changes in our society.*

Slovic points to recent advances in information technologies that have increased the power of various forms of news media. Often, the media can bring us information about events as they happen, and we have already discussed their propensity to report negative information. He describes another important social phenomenon, the rise in power of special interest groups. Armed with financial and information resources, they have a strong influence upon the public and Washington. Most importantly, their own agendas can radically alter public opinion and policy decisions. Further, relying upon the "hard" sciences to reduce our worries about the potential for catastrophe or ill health regarding hazards is a dangerous strategy. In the absence of trust, science only fuels distrust by uncovering new risks or alternative positions.[56] This only serves to heighten the uncertainties involved. Our participative democracy allows an unbridled, "information assault" upon the public by various individuals, agencies, businesses, industries and even the government itself. This assault results in a beleaguered and confused society.

---

[56]Ibid., p. 680.

4.8 Risk Communication and Market Direction in Remediation

So what does all this mean for remediation organizations? Foremost, societal risk perceptions are the result of the interplay between psychological, social and political processes. Successes or failures in risk management are highly correlated to the managers understanding or misunderstanding of this phenomenon.[57] Psychologically, society is most uneasy about hazards that are found in the upper right quadrant of Slovic's cognitive map. Wastes handled by remediation organizations fall into this category. In addition, the resulting solutions for reducing or eliminating the risks such hazards threaten are accepted or rejected by society in accordance with the trust it places in the problem-solver. Socially, the rise in significance of information systems, the media and public interest groups dramatically influences individual perceptions of risk. The slant of the material provided by such groups toward negative information further destroys the trust society places in its institutions and creates seeming hysteria about controversial topics. Finally, our participative democracy reinforces such information exchange. Society hungers for complete and decisive information, but the resulting interchange often presents alternative and conflicting views that exasperate and confuse the public.

With the near unconquerable challenge posed by society's risk perceptions, how should organizations approach risk communication? Slovic argues that the first and most critical step is the restoration of trust:

> *Restoration of trust may require a degree of openness and involvement with the public that goes far beyond public relations and "two-way communication" to encompass levels of power sharing and public participation in decision making that have rarely been attempted.*

Certainly, this is still no guarantee for success, but it appears a necessary step. Both industry and the public will have to replace their existing biases with unprecedented cooperation. Essentially, each element must create a new way of viewing and thinking about the other. Given the reinforcement current prejudices have received, this is no easy task. Additionally, no algorithm or formula exists to provide a solution. Instead, all elements of society must evaluate themselves and their interrelationships contextually, forcing themselves to open doors that are tightly shut. As long as industry and the public are willing to sit together as peers, there is hope for possible solutions to the seeming problems that beleaguer society.

---

[57]Ibid., p. 681.

Slovic's insight questions the success of future public policy that emphasizes ecological risk management based upon "real" rather than "perceived" risks. As discussed in chapter two, forecasters expect as science and public and policy-maker understanding of the true extent of ecological risks get better, spending priorities and regulatory emphasis will change.[58] Slovic might argue that we cannot dismiss societal perceptions; more importantly, doing so has resulted in stagnation for worthy efforts like nuclear energy. The shift toward containment rather than cleanup services and technologies is dependent upon changes in public policy. Basically, we find ourselves at an impasse. Will societal perceptions and concerns prompt this change? The 1994 Congressional elections indicate society's desire for less government and spending. Does this outweigh the apparent distrust of government-lead risk management and communication efforts? Predictions are difficult, but I still expect the 1996 Presidential election is an adequate barometer as discussed in chapter three. Until then, I foresee two alternative courses of action. First, the federal government may grant more authority to the states for cleanup program oversight and administration. If this occurs, the diversity of the remediation market will dramatically increase. Second, program funding may be cut substantially. In this case, containment and monitoring needs will skyrocket. Since the industry will certainly pressure government for maintenance of some sort of regulatory consistency, I suspect the second alternative is more likely.

Regardless of the future of public policy, handling societal perceptions remains quite significant. Desmond Conner, a Ph.D. sociologist and president of Connor Development Services, Ltd. in Canada, has consulted with numerous corporations about strategies for public involvement on over 200 projects over the past twenty years. He recommends a simple, four-point model for virtually any public involvement effort. The first step is a social profile where an organization conducts a thorough survey of the community to understand "what they need and think...so often public relations professionals rush into action without understanding what makes the people in the area tick."[59] An organization must learn the community's history, issues, and attitudes about the proposed project. Next, Connor recommends creating a responsive publication that provides residents with understandable answers to their questions in the comfort of their homes. Brochures or newspaper ads are appropriate, but regardless of the form, some method of return communication must exist, either a tear-off coupon or a telephone number for questions. People must be able to "respond with their questions and concerns. It's got to be two way

---

[58]TechKNOWLEDGEy Strategic Group. "What Happened to the Environmental Business?", December 1993, p. 15.

[59]Anonymous. "A Clear Strategy for Public Involvement", Environmental Manager, June 1993, p. 8.

communication." He warns that the worst possible first move is to call a public meeting early since people often come to the meeting ignorant and unprepared, so "you've got a recipe for disaster".

Following the publication, an organization should conduct an open house to give the community the opportunity to ask questions and talk one-on-one or in small groups in the organization. Open houses afford members of the community the chance to gather the information they want rather than be forced to sit through a possibly irrelevant meeting. Tours, exhibits, or texts are appropriate for promoting "a conversational and not a confrontational experience." Finally, a planning workshop is conducted. Here, a broad spectrum of the community is involved to begin problem solving and compromise. Often, single-interest groups are neutralized if the group's representation is diverse. The goal of this step is an agreeable plan for the vast majority of the community. Connor does recommend step repetitions as necessary. For example, a planning workshop may discover several possible alternatives, and it might make sense to inform the entire community through another responsive publication and proceed again.

4.9 Summary

This chapter has examined the approaches to risk management of several US remediation firms. This research suggests that approaches emphasizing retention and loss prevention are most appropriate for strategic planning. In addition, traditional risk management methods are adequate for the current remediation environment; however, remediation firms appear unprepared and hesitant to involve the public in risk communication efforts. Accordingly, the remainder of the chapter examined societal risk perceptions within the interplay of psychological, social and political processes. Research into these perceptions identifies several significant observations. First, expert and lay attitudes toward risk differ dramatically. Expert evaluations of risk usually correlate to total annual fatalities while lay judgments generally relate risk to other hazardous characteristics such as catastrophic potential. Second, society is most uneasy about hazards such as those handled in remediation, and these hazards create the greatest societal impact because of the perception that they signal future tragedy. Third, society has limited trust in the institutions responsible for risk management and communication. This lack of trust dooms the majority of these efforts. A possible step to reestablish this lost trust is open dialogue between the public, government and industry. Each must lend credibility to the other and cooperate in an unprecedented manner. Accordingly, a four-

point plan--social profile, responsive publication, open house, planning workshop--for public involvement was presented as an alternative for implementation.

Chapter 5
TECHNOLOGY DEVELOPMENT AND TRANSFER

As the births of living creatures at first are ill-shapen, so are all innovations, which are the births of time . . . Surely every medicine is an innovation; and he that will not apply new remedies must expect new evils; for time is the greatest innovator.

- Francis Bacon

5.1 Overview

Initially, the staggering dimensions of our nation's hazardous waste problem produced a substantial need for effective ecological technologies. Developers hustled to respond, but found an intricate environment for commercialization. Regulatory and financial barriers keep technology development stifled. In addition, EPA's record of decision (ROD) process is rather risk averse since section 121 of CERCLA requires remedial actions to comply with all applicable or relevant and appropriate federal and state requirements (ARARs), be cost-effective, and use permanent solutions.[60] As discussed previously, I expect a shift in demand toward containment rather than cleanup technologies. Perhaps, stabilization and bioremediation methods will gain prominence. Our following discussions will highlight their applicability for cost efficiency. Given such an uncertain and difficult development environment, understanding the existing situation lends insight into possible changes in the future. Accordingly, this chapter will briefly discuss existing remediation systems and technologies and examine innovation sources, barriers, and incentives. Finally, alternative transfer mechanisms for reducing communicatory barriers are analyzed.

5.2 Remediation Technologies[61]

For the majority of the century, wastewater treatment was about the only existing technology. Today, ecological technologies require classification into either remediation,

---

[60]Hoffman, A. "Commercializing Remediation Technologies Fraught with Incentives, Obstacles", HAZMAT World, February 1992, p. 51.

[61]Details were constructed from: Hoffman, A. The Hazardous Waste Remediation Market: Innovative Technological Development and the Market Entry of the Construction Industry. Thesis submitted to the Department of Civil and Environmental Engineering, MIT, Cambridge, MA: August 1991; and Moavenzadeh, F. Global Construction and the Environment: Strategies and Opportunities. New York, John Wiley & Sons: 1994.

pollution control or pollution prevention. Obviously, our discussions will focus upon remediation technologies. Generally, remediation approaches are threefold: in-situ systems, prepared-bed systems, and in-tank systems. An in-situ system is as exactly as its name implies, one where contaminants are treated on-site as they are "situated". A prepared-bed system is one where either the contaminants are removed to a prepared site for containment or treatment, or the contaminants are removed to a temporary location, the original site is prepared for treatment, and then, the contaminants are returned for treatment. Finally, an in-tank system is one where contaminants are removed for treatment in an enclosed reactor. Beyond the system approach, remediation technologies usually employ five techniques: thermal treatment, solidification/stabilization, physical separation, chemical treatment, or bioremediation. Our following discussion will examine each in more detail.

5.2.1 Thermal Treatment

Thermal treatment is either high temperature or low temperature. High temperature treatment applies 2,500-3,000°F temperatures to destroy or breakdown contaminants into other compounds. Organic contaminants such as dioxin or PCBs are especially applicable for high temperature treatments, but the cost of this treatment is extremely high since additional fuel is necessary to maintain combustion. In addition, these treatments require secondary systems to handle the resulting flue gas, fly ash, and filter dust. Incineration, pyrolysis, wet oxidation, and vitrification are four types of high temperature thermal treatments. Incineration destroys combustible contaminants at temperatures above 2,200° F; pyrolysis decomposes organic contaminants in an oxygen deficient atmosphere; wet oxidation destroys organic contaminants at high temperature and pressure in a liquid solution; and, vitrification destroys organics and immobilizes inorganics within melted glass. Current innovations in this technique include in-situ vitrification. Low temperature treatment exercises temperatures between 200-900°F to separate organic contaminants from the carrying medium (soils, sludges, etc.) through evaporation. Essentially, the heat removes the contaminants from the soil or sludge, and then the contaminants are destroyed in an incinerator. Low temperature techniques are less costly than high temperature ones. In-situ low temperature thermal treatment is a developing application.

5.2.2 Solidification/Stabilization

Solidification/stabilization reduces contaminant mobility by adding or mixing materials into the carrying medium. This technique is particularly applicable for inorganic heavy metal contaminants, but it is susceptible to leaching. Solidification changes the physical characteristics of the contaminated area, resulting in a monolithic block of material following treatment while stabilization simply restricts contaminant mobility by adding and mixing materials into the contaminated area without changing its physical characteristics. Some examples are cement-based solidification and pozzolanic stabilization. The former seals the contaminants in Portland cement, and the latter binds the contaminants in a lime and siliceous matrix. Current innovations in this technique include glassification, combining contaminants with molten glass, and ion exchange, replacing contaminant ions with innocuous ones.

5.2.3 Physical Separation

During physical separation, contaminants are separated from the carrying medium through volatilization, extraction, or filtration. Volatile organic compounds (VOCs) are quite applicable for this technique. Two examples are in-situ soil vapor extraction and soil washing. In-situ soil vapor extraction removes VOCs from the soil by applying a vacuum through a production well, forcing compounds to diffuse into the well. Soil washing extracts contaminants from excavated material by the insertion and removal of liquids such as water or acid. At MIT, a technique called electro-osmosis is under current research. Electro-osmosis applies an electric field to a contaminated area, forcing water to move throughout the area thereby extracting the contaminants. Subsequently, the water is removed and treated.

5.2.4 Chemical Treatment

Chemical treatment destroys or detoxifies contaminants through chemical oxidation or reduction. Organic contaminants are especially applicable for this technique, but in-situ applications are unusual since they are difficult to control. As a result, in-tank systems are normally employed. Oxidation techniques introduce materials such as ozone or hydrogen peroxide to oxidize the contaminants. Reduction techniques have limited applications but may prove viable for some heavy metals.

5.2.5 Bioremediation

Bioremediation uses bacteria, fungi or other microorganisms to detoxify contaminants. This technique has long been exercised in wastewater treatment and is quite cost-effective. Some estimates say its cost is $100 per ton compared to $1000 per ton for such techniques as incineration. It requires, however, very controlled conditions and takes quite a bit of time for completion. During normal implementations of bioremediation, native microorganisms are extracted from the contaminated area, evaluated for their applicable uses, colonized to increase effectiveness, and re-introduced to the area to affect the cleanup. This technique is gaining popularity especially in remote sites where time is not significant.

5.3 Innovation

Recently, I took a course in managing technological innovation. In it, we defined innovation as invention coupled with exploitation, so innovation is not simply having a great idea, but also having the capacity to implement it. As the US remediation market blossomed, a new arena of technological needs developed. Remediation does not present a difficult technological challenge. The trend toward less design work in phases of remedial work and the possibility of presumptive remedies suggest the limited technical challenges involved. Once a site is characterized, multiple alternatives are available for action. In fact, characterization may be the most challenging phase of remedial work. Often, contaminants are underground, so understanding them is difficult. Indeed, my geotechnical professor during my undergraduate studies mentioned that soils analysis and design is often more art than science. In addition, contaminants are rarely homogeneous; often, they are heterogeneous mixtures of various forms of waste. Beyond this is public influence. Public interest in proposed solutions can affect a technology's acceptance. Clearly, public acceptance of a technology will influence its demand. The remainder of our discussions in this section of the chapter will focus upon marrying the invention with exploitation; we will examine the sources of the invention and both barriers and incentives to their exploitation.

5.3.1 Sources of Innovation

Generally, the invention of remediation technologies is occurring in five areas: universities, national laboratories, remediation technology vendors, ecological service

firms, and private firms (other than ecological services). Not surprisingly, the nation's universities are active participants in the invention of remediation technologies. For example, the catalytic extraction process (CEP, commonly referred to as molten metal technology) that dissolves wastes in a 3,000 degree F bath of molten metal was created at MIT. In addition, we have already discussed on-going MIT research in electro-osmosis that employs physical separation techniques. Various national laboratories are involved in remediation invention. Following the end of the Cold War, interest arose in utilizing the vast defense and weapons research infrastructure for commercial applications. In 1986, the Federal Technology Transfer Act was passed which allowed national laboratories to collaborate with other agencies and private industry through cooperative research agreements. Today, multiple DOD and DOE laboratories are actively involved in remediation technology development. DOD laboratories such as the Army's Construction Engineering Research Laboratory and the Navy's Civil Engineering Laboratory diligently engage in development and technology transfer activities. Similarly, DOE's new Enterprise Program looks to advance the same objectives. Remediation technology vendors such as Massachusetts' Groundwater Technology, Inc. specialize in the development and application of remediation technologies. Molten Metals Technology, Inc. (the firm created to exploit CEP) is another. Ecological service firms also engage in technology development. Clean Harbors Environmental Services develops and implements in-situ remedial techniques while Metcalf & Eddy, Inc. offers a diverse portfolio of technologies. Finally, private firms may occasionally develop remedial technologies. For example, Texaco invented a technology to assist in its own remedial efforts. Uninterested in its commercial exploitation, Stone & Webster approached Texaco and acquired it for commercialization.[62]

5.3.2 Barriers to Innovation

Certainly, the sources of innovation are not quite as defined as I have presented them. The elements are interwoven by temporary alliances, consortia, or cooperative agreements, but the diversity of the sources only enhances the complexity of their exploitation. Communicating and demonstrating a technology's advantages is arduous. Diffusion of the information about a technology is an ever present challenge. Fortunately, a large percentage of remedial work is in the public sector, and disclosure of information

[62]Information presented by James Cleveland, President, Stone & Webster Environmental Technology & Services, during the *Center for Construction Research and Education's Roundtable Workshop on Risks and Opportunities in the Hazardous Waste Remediation Market* at MIT on November 10, 1994.

on public remediation projects is required. From this perspective, the communication barriers are lessened, but the collection and dissemination of information remains difficult. Funding the exploitation is a bit deviant from normal technological development. The tenuous liability issues can deter financial institutions and venture capitalists from investing in remediation technologies. The strict, joint, and several liability doctrine discussed in chapter 2 could possibly shed responsibility for damages upon financiers. The uncertainties involved will preclude all but the most aggressive risk seekers.

Additionally, the regulatory structures are quite unpredictable. Cleanup standards today might change tomorrow. Further, state requirements are variable and might be more stringent than national standards. Indeed, one swipe of the legislative pen can all but extinguish a technology. In fact, this barrier is probably the most significant, and the regulatory winds of ecological policy change appear reluctant to subside. Inherent in the regulatory structures are the pervading public opinions and perceptions. I have formerly documented examples of public opposition, so I shall not expound upon them here. Suffice it to say that public opinion can dramatically influence the acceptance or rejection of a remediation technology (of course, this may be said about any technology, but the implications a remediation technology might have upon an individual's future health is a bit different from the features offered on an electronic device). As a result of the interplay amongst the technical, communicative, financial, regulatory, and societal barriers, remediation technologies require significant demonstration. This, in itself, is a barrier. Yes, it is also a phase of exploitation, but the extent of demonstration necessary creates its own funding and communication requirements.

5.3.3 Incentives for Innovation

To reduce the barriers to innovation, I place incentive programs into two basic categories, finance and communication. Financial incentives are primarily government lead programs that offer tax credits or funding for innovative activities. Since 1981, the federal government has allowed industry a 20% R&D tax credit.[63] Additionally, the government may offer the end user of a technology a tax break. More common programs give funds to developers. For example, the EPA's Superfund Innovative Technology Evaluation (SITE) program is designed to enhance the development of remediation technologies. The first phase is the *Emerging Technologies* program where the EPA will match a developers investment in a potentially viable technology up to $150,000 per year

[63]Moavenzadeh, F. Global Construction and the Environment: Strategies and Opportunities. New York, John Wiley & Sons: 1994, p. 127.

for two years. If pilot tests during the first phase are encouraging, the second phase, *Demonstration*, is initiated where the technology is field tested to collect engineering and cost data to determine if it is applicable for cleanups. Joint EPA and developer costs can range from $600,000 to $1.5 million during demonstration.[64] Other phases of SITE include *Technology Transfer* and *Measurement and Monitoring Technology Development*. Private groups, although not very common, are also beginning to finance technology development. In California, a non-profit group, the Institute for Environmental Solutions (IES), wants to create a $100 million lending pool for financing various redevelopment tasks such as site remediation, technology commercialization, and regulatory oversight.

In addition to financial incentives, communication programs hope to facilitate technology transfer. Again, government-lead programs are predominant. The EPA established the Alternative Treatment Technology Information Center (ATTIC) in 1989. This automated database hopes to provide on-line information about technologies to interested parties. A second database, the Vendor Information System for Innovative Treatment Technologies (VISITT), provides current information about the availability, performance, and cost of innovative processes. Currently, EPA's Region One is toying with an idea of creating an information center that would incorporate all dimensions of remediation into one location. Anyone could find all sorts of information ranging from cleanup project summaries to technology development activities in the center.[65] In addition, cooperative research agreements between private industry and national laboratories allowed under the Technology Transfer Act also hope to diminish the communication barriers, and numerous government agencies prepare written documents for distribution and dissemination of technological information. For example, the US Army Corps of Engineers Toxic and Hazardous Materials Agency published a comprehensive guide to remediation technologies entitled *Installation Restoration and Hazardous Waste Control Technologies* in 1992. Finally, consortia or alliances such as HWAC can enhance technology transfer.

---

[64]Anonymous. "Fear of Trying", Civil Engineering, April 1991, p. 54.

[65]Information from the *Center for Construction Research and Education's Consortium on the Global Environment and the Construction Industry Research Group Meeting*, April 1994, where members of EPA's Region One were in attendance.

5.4 Fostering Innovation through Technology Transfer Mechanisms

Neither organizations nor the EPA can create the regulations that may result from Superfund's reauthorization and beyond. Policies that eradicate developing or developed technologies are possible, so nearly their only course of action is to keenly monitor regulatory developments as proactively as possible and plan accordingly. Both organizations and the EPA, however, can change their approaches to technology transfer. With the breadth of the nation's hazardous waste problem and the countless organizations involved in its rectification, the country faces a tremendous challenge in transferring the knowledge of technological developments across it. I hope to address these communication problems in the remainder of this chapter. Formerly, we have discussed several federal programs aimed at facilitating technology transfer, but I am hesitant to endorse their potential for enhancing communication. Perhaps, our EPA should take a different approach to technology transfer and communication. Several studies advocate bridging communication gaps by either procedural, human, or organizational approaches.[66] We shall investigate two potential approaches: first, a specialized transfer group, and second, informal information sharing.

A specialized transfer group would collect information about various innovations throughout the country, preparing technical reports for distribution. In addition, it could act as a "technical service" agency to assist during implementation of new technologies. This approach is adopted often, and the EPA's ATTIC or VISITT program's provide examples. In theory, this approach to technology transfer seems plausible, but in reality it has several limitations. Given the diversity of the sources of innovation, it is unrealistic to expect the transfer group to find all the pertinent information itself. Subordinate agencies or firms would have to report some information about solutions or problems to the transfer group. While this sort of reporting will probably occur through normal regulatory control channels, its value to assist in technology transfer is questionable. One, the timeliness of such reports is critical. The innovative organization is not likely to file the report until they have found and implemented their solution. Meanwhile, a separate organization may toil over the same problem, wasting time and resources while searching for a solution.

Aside from the time involved, the value of printed information as a source for new ideas is limited. Research of engineering project teams demonstrated that only 11% of the

---

[66]Katz, R. and Allen, T., "Organizational Issues in the Introduction of New Technologies", in Katz (ed.) Managing Professionals in Innovative Organizations, Cambridge, MA: Ballinger, 1988, p. 450.

sources of new ideas and information could be attributed to written media.[67] Given this limitation, how effective can a transfer group be if it only provides written information across the nation? Of course, the transfer group could provide a telephonic hot-line or computer database for information, but this does not solve the timely collection problem. Such limitations gave rise to the idea that the transfer group should do more than just collect and distribute information. It should also act as a technical service agency during implementation of new technologies, actually providing training for others. If the transfer group takes on this responsibility, the breadth of skills required dramatically increases. No longer does the transfer group just need collection and communication skills, but it now needs specific technical skills. This presents two problems. First, what technical skills should the group have, and second, where should the group get the people with these skills?

A second proposed alternative is informal information sharing. Numerous studies have consistently shown that the bulk of critical outside contacts comes from face-to-face interactions among individuals. Interpersonal communications rather than formal means are the primary method for the collection and transfer of information by engineers into their organizations and project groups.[68] This informal sharing of information seems to provide a possible answer to the nation's problem. Unfortunately, facilitating this interaction is not a simple task.

Schrader investigated this informal sharing of information at the firm level as a technology transfer mechanism in 1990. He concluded:

> *Employees are less inclined to provide a specific piece of information if doing so is likely to considerably hurt their firm's ability to capture economic rents from the information; they are more willing to provide information if they can expect to receive valuable information in return. In addition, the evidence suggests a positive link between informal information trading and a firm's economic performance.*

These observations have interesting implications for the proposed transfer mechanism. Here, my thought is an EPA-facilitated technology network where informal sharing of information amongst the network's constituents occurs regularly. Later, we will discuss the network in more detail, but let's first consider its applicability.

The intensity and diversity of competition is quite variable amongst the innovation sources. Here, Schrader identifies three factors which influence the degree of information transfer: 1) the degree of competition between the involved firms, 2) the availability of

---

[67]Ibid., p. 444.
[68]Ibid., p. 444.

alternative information sources, and 3) whether the information relates to a domain in which the involved firms compete. Now, while competition is quite evident among technology developers, they and the EPA share a common mission, creating and implementing efficient and effective cleanup technologies. This factor should enhance cooperation, but the situation amongst individual organizations is quite contextual, so predicting the degree of this factor's influence here is difficult. Now, the characteristics of the remediation technologies make their availability medium to high. Currently, variability in techniques is somewhat limited. Our discussions previously lump remediation technologies into only three system categories, prepared-bed, in-situ, or in-tank. Further, the use of thermal, washing, or separation techniques are predominant, so, generally, one organization hoping to receive information from another could develop a similar solution to the problem at hand with some, but not substantial, difficulty. This encourages cooperation. The influence of the final factor is not clear. Its influence is absolutely situation dependent, but the somewhat favorable influence of the other factors seems to promote the informal transfer of information.

If the competitive environment is favorable, organizations should transfer information if they can expect benefit from the transfer. Again, Schrader identifies three additional factors which influence the degree of transfer: 1) the likelihood that the information receiver will reciprocate information, 2) the value of the transferred information to the information receiver, and 3) the technical expertise of the information receiver. These factors are closely associated. For example, if I transfer information to the receiver, and he places a high value upon this information; the more likely he is to reciprocate in the future. In addition, it is in my interests to transfer information with a receiver who has high technical expertise because he will likely reciprocate useful information. Since these factors are highly dependent upon the situation, it is difficult to predict their influence upon information transfer. They do, however, provide insights into organizational relationships. Organizations which trade information will, generally, have comparable technical abilities; those which lag behind cannot participate in the informal information loop. More importantly, organizations at the technical forefront stand to gain the most from sharing information.

Given these insights, relationships become the critical success factor for informal information sharing. By facilitating beneficial relationships, our country stands to gain tremendously in its capacity to transfer knowledge. Tushman's research into the communication patterns of high performing innovation projects provides some additional insight. He might classify innovation of remediation technologies as *development projects* where the project is locally defined yet the involved technologies are not well understood.

Clearly, some elements of remedial solutions are site specific such as the geotechnical conditions, but the solution designed given the contaminant is substantially more generic. In other words, a new remedial solution is not required for each and every sight. For this reason, I argue that innovation of remediation technologies fits his definition of *development projects*. Tushman concluded that in such cases communication with elements outside the organization focused upon operational issues mediated by a few boundary-spanning individuals. In a stable organizational environment, the amount of external communication was moderate, but as environmental turbulence increased, the more the effort relied upon boundary-spanning individuals to acquire external information. From this conclusion, identifying and developing these boundary-spanning individuals, the gatekeepers, is necessary for establishing these relationships.

5.4.1 The Technological Gatekeepers

Since it appears that communication with external elements is necessary to supplement the staffs of organizations in particular areas, this support should be planned and engaged on a long-term basis.[69] Certainly, the concept of technological gatekeepers is not new, but implementing the concept to facilitate information transfer remains difficult at best. Four dimensions require further examination:

- identifying existing gatekeepers
- resourcing the gatekeepers to facilitate external interaction
- creating the appropriate incentives for the gatekeepers
- replacing the gatekeepers as they advance, retire etc.

Normally, gatekeepers are well-established members of their organizations who have the respect and trust of subordinates and peers alike since their technical performance is superior. Given their level of expertise, they have probably advanced to at least the level of first-line supervisors. They already have connections outside of the organization, but they are generally not recognized formally as the organization's technical link with the outside world. Allen concludes that with a little thought technical management can generally guess accurately who their gatekeepers are.

Once identified, the organization should take full advantage of their talents. Accordingly, the organization should resource gatekeepers to enhance their external contacts. Resources should be available for attendance at technical conferences, for visits to other facilities, and for the collection and dissemination of information. One might

[69]Allen, T., Managing the Flow of Technology: Technology Transfer and the Dissemination of Technological Information within the R&D organization, Cambridge, MA: MIT Press, 1977, p. 141.

expect that such investment in a single individual could cause jealousy and contempt amongst co-workers within the organization. Certainly, this is possible. If organizations, however, correctly identify their gatekeepers, then the benefits they return to the organization and its workforce should transcend this concern. Additionally, the proper structuring of incentives can prevent such prejudices from developing. A reward system structured around group or team accomplishments not only will prevent such problems but it will also encourage interaction, interaction by the gatekeeper with external elements and interaction by the workforce with the gatekeeper. Each needs the other to succeed. Finally, replacing gatekeepers may be the most challenging task. In some cases, gatekeepers may be content to work in this role for the duration of their careers. In such instances, replacing them is a lesser concern. Gatekeepers, however, are high performers, and they are certainly capable of advancing in an organization. Here, finding new people to fill these roles is critical especially as organizations grow to depend upon them. An effective approach is a mentor program. Early on, organizations should select individuals best qualified to fill the gatekeepers' roles. The current gatekeepers should have significant influence in this decision process since they are the ones responsible for training their replacements. By involving the gatekeepers in the selection, the more likely they are to fully divest their expertise to their replacements.

5.4.2 Relationship Building

Clearly, any organization involved in technology development must identify and value its gatekeepers. These individuals need the resources and authority to establish the external relationships so necessary for the transfer and receipt of knowledge. Each organization can facilitate this relationship building. One alternative is the horizontal rotation of personnel throughout the organization, so over time these relationships are built amongst individuals. The danger in this strategy, aside from the negative social consequences for the individual, is that the individual may never infiltrate the power structure of any particular organization. He remains an outsider, so even though he may have fresh insight or multiple contacts, he is not in the position to actually influence the organization, a quality necessary in a gatekeeper. Another alternative is joint problem-solving meetings. If a particular issue is common amongst organizations, meeting within a cooperative environment can serve dual purposes. First, the problem at hand may get solved, and second, informal relationships are built amongst team members. Finally, events such as seminars, technical fairs or the like can help establish these informal relationships.

The nation should develop a gatekeeper network under EPA's guidance. Instead of financing the creation and maintenance of information centers and information databases, EPA could sponsor and fund an aggressive workshop and seminar network. First, EPA should lead open invitation workshops and technical conferences. Second, EPA must encourage organizations to establish their own gatekeeper networks to provide the communicative support necessary for innovation in the long-term. The EPA might grant funds to organizations to lead their own conferences or workshops with the stipulation that some percentage of their workshops must be open invitation to anyone interested. Accordingly, organizations must exhaustively consider the identification, the resourcing, the incentive, and the replacement implications discussed previously. Third, the EPA or organization-lead technical conferences should highlight significant problems in remediation technology development. These conferences should remain informal events to encourage maximum interaction in a relaxed environment. Hence, professional reputations are not in question, and proposals are not challenged. Instead, conference members can thoughtfully exchange information and ideas without inhibition. Finally, the EPA and organizations should invite the interaction of their supply and user communities to receive additional insight and feedback.

5.4.3 The Stages of Technology Transfer

Aside from the strategy of relationship building, the organizational technology gatekeepers should understand the stages of technology transfer. This understanding will prepare them to assist in managing the introduction of innovations into their organizations. By examining the stages of transfer, one will comprehend the potential barriers to adopting an innovation. Additionally, as a more comprehensive strategy for technology transfer evolves within the EPA and into the private sector, this understanding will allow the proper structuring of incentives to overcome these obstacles.

Five steps are generally described in the technology adoption process:[70]

- knowledge
- persuasion
- decision
- implementation
- confirmation

[70]The following discussion of the stages of technology transfer is taken from: Jain, R. K. and Triandis, H. C., Management of R&D Organizations: Managing the Unmanageable, John Wiley & Sons, New York, 1990, p. 186-187.

The *knowledge stage* is a discovery process for the technology's potential user. Here, the user becomes familiar with the innovation, determining its capabilities and limitations. The *persuasion stage* describes the action of the user as he/she forms a favorable or unfavorable opinion of the innovation. The user evaluates the relative advantage of the innovation over current methods, techniques, products etc. The *decision stage* occurs when the user acts to adopt the innovation. The *implementation stage* is the process of incorporating the innovation into the user's activities, and finally the *confirmation stage* is the evaluation of the innovation's implementation and the decision for continued or discontinued use of the innovation.

Obviously, the adoption process for an innovation is complex. Our previous discussions of transfer mechanisms and gatekeepers only address the knowledge stage while providing partial insight into the persuasion stage. The gatekeeper network will regularly engage in knowledge and persuasion activities as they search for potential innovations. A more complete analysis must examine the organizational responses to innovation. Accordingly, the technology gatekeepers must assess the potential innovation's position relative to their own organization's competencies. Nearly all innovations will either destroy or enhance existing competencies.

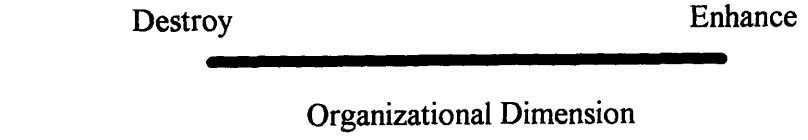

Figure 7. Predicting Organizational Response to Innovation

Figure 7 depicts a tool for predicting organizational response to an innovation.[71] By selecting any organizational dimension, the gatekeepers can determine how different elements of their organization will react to a particular innovation. In addition, it is a simple but valuable aid during the persuasion and decision stages of transfer. First, the gatekeepers should evaluate the pertinent dimensions of their organization relative to the

[71]This tool is adopted from a concept introduced by Abernathy and Clark. Further discussion can be found in Abernathy, W. and Clark, K., "Innovation: Mapping the Winds of Creative Destruction" in Tushman, M. W. and Moore, W. L., Readings in the Management of Innovation, 2nd edition, Cambridge, Ballinger, 1988.

innovation. Second, the relative advantage of the innovation must outweigh the predicted organizational resistance. Some innovations just may not fit. If all or most of existing competencies are destroyed, then, in essence, the organization will likely be destroyed. This situation, however, may indicate the necessity for organizational change or advancement, an aspect for consideration during strategic planning. Third, if the innovation is worthy of introduction, then the gatekeepers must plan for its implementation. Here, effectively managing the change is essential.

Obviously, a significant element of change management is communication. Initially, the gatekeepers should focus on creating a team which supports the change. Informal recruiting of people throughout the organization that will support the change will assist in diffusing the appropriate information. Critical to this effort is creating a joint purpose, so all elements of the organization will view it as a team effort. Additionally, the gatekeeper should always present the change as incremental, no matter how radical it may seem. The "old way of doing things" has an abundance of positive reinforcement within the organization, and breaking its hold will prove difficult. Gatekeepers should focus upon communicating the benefits of the change, finding some benefit for everyone. They should be prepared, however, to discuss its disadvantages. Avoiding the issues will only heighten skepticism. Finally, gatekeepers should avoid yes/no decisions from management regarding the proposed changes. If the decision is no, then they have exhausted their options. This discussion is in no way a formula for success, far from it. Change management is a monumental venture. The gatekeepers must, however, avoid haphazard introduction of innovations. Without proper planning for its implementation, the effort will almost certainly fail.

5.4.4 Other Considerations

Research conducted following the implementation of the Federal Technology Transfer Act of 1986 provides some interesting information about such interactions. In 1988 and 1992, a joint effort by Georgia Tech and Lehigh University surveyed 101 laboratory and division directors from 68 member companies of the Industrial Research Institute (IRI) concerning their interaction with federal laboratories.[72] Ten methods of interaction were studied ranging from contract research to information dissemination. Their results have interesting implications for the Army's future transfer policy. Informal interactions were the most common such as information dissemination, lab visits, seminars and technical

[72]Roessner, J. D. and Bean. A. S., "Industry Interaction with Federal Labs Pays Off", Research and Technology Management, September-October 1993, p. 38.

consultation. Interestingly, the frequency of such interactions increased from 1988 to 1992, so the relationship between industry and national laboratories has bred collegiality.[73] The researchers also asked the 62 division directors who said their labs had at least moderate levels of interaction to rank the ten ways of interaction in terms of their overall value to the division or lab, where overall value was defined as not simply direct economic value or return-on-investment alone. Contract research ranked first in this category followed by cooperative research. Additionally, they asked the directors to record the form the payoff most frequently took. Table 7 summarizes these results:

Form of Payoff	***Contract Research*** respondent percentage	***Cooperative Research*** respondent percentage
profit potential or business opportunity	33%	<10%
leveraging R&D, risk sharing	--	33%
support on-going research projects	12%	--
access to expertise and knowledge	50%	50%

Table 7. Results of Industry/Federal Lab Interaction Survey

Finally, the researchers asked the directors which method of interaction holds the most promise in the future for their organizations. More than 70% responded that cooperative research holds the most promise.

This research insights several implications for the EPA strategy. Since informal interactions have proven the most frequent, this supports the concepts introduced earlier advocating establishing an informal gatekeeper network. Further, wherever possible it should allow the fullest interaction. Visits to private facilities, the exchange of technical papers, and marketing "consulting services" should become the norm for national laboratories. Realizing the potential value of cooperative research to private industries, the EPA should encourage labs to market their technical expertise and knowledge while encouraging cooperative research agreements allowed by the Federal Technology Transfer Act.

[73]Ibid., p. 39.

While achieving the highest return on the nation's research investment dollar is certainly a noble goal, our laboratories must balance this emphasis with their overall research mission. Too great an emphasis upon transferring technologies into the private sector will certainly hinder basic and applied research efforts. Coursey and Bozeman investigated the effects of this emphasis upon government laboratories in a 1992 study. While their results found that government laboratory directors had a generally optimistic opinion about the payoffs from technology transfer, the disadvantages of this emphasis varied depending upon the type of research on-going in the laboratory. Their results are summarized in the following table:

Type of Research	*Effects:*		
Basic	-changed lab research agenda	-took time away from other research	
Applied	-changed lab research agenda	-took time away from other research	-greater interruption from outsiders
Development	-little if any effects		

Table 8. Effects of Technology Transfer on Government Labs

While any of the three research types can certainly participate in technology transfer activities, the basic and applied research efforts stand to lose the most from such activities. The nation must carefully consider how involved each of its various research laboratories should get in technology transfer. Clearly, more basic and applied research groups need involvement in this effort, but a cautious approach is advisable. Maintaining their current research agendas may prove more important.

5.5 Summary

This chapter has introduced an EPA-facilitated informal gatekeeper network as a method for transferring technologies throughout the nation. EPA should invest in creating relationships among the remediation technology community as a technology transfer mechanism rather than the specialized transfer group mechanism that ATTIC and VISITT represent. As relationships are built, an informal network will evolve that allows more timely and effective communication. EPA should host seminars, technical conferences, and the like to begin relationship building. In addition, the stages of technology transfer

are significant for understanding the barriers to innovation adoption and the structuring of incentives to overcome them. Finally, the emphasis upon technology transfer has several disadvantages for basic and applied research groups; development groups seemed best-suited for involvement in the transfer of remediation technologies.

Chapter 6
FUTURE ORGANIZATIONS

Every government degenerates when trusted to the rulers of the people alone. The people themselves are its only safe depositories.

Experience hath shewn, that even under the best forms of government those entrusted with power have, in time, and by slow operations, perverted it into tyranny.

- Thomas Jefferson

6.1 General Discussion

At this point, we depart from our discussion of secondary trends, current industry responses, and recommendations for improvement. We return to the dominant trends as we look to form an organization of the future. Recalling our previous definitions, sustainable development allows present society to meet its own needs without compromising the ability of future generations to meet their needs, and decentralization is flexible organization through competency discovery, development, and complementation, lateral coordination, and autonomous decision-making. In what sense do these paradigms influence remediation? Why should a remediation organization care about them? First, the necessity of the sustainable development discussion is clear. Remediation services are a segment of the ecological service industry. The industry's future relies upon trends in ecological management, and sustainability is its evident future. Preparing for and responding to this future will enhance any member's position upon its arrival. Second, decentralization offers the flexibility and autonomy necessary for remediation work. Our discussions from chapters two through five highlighted the diversity of remediation markets. Foremost, the regulatory environment is quite confusing. National statutes are complex enough, and states and municipalities further complicate the matter with their regulation complements. Remediation sites themselves are distinct. Site conditions require custom designs although as experience is acquired standard "recipes" are becoming possible. Still, each site requires some measure of characterization before work can begin. Community response to a remediation project is rather variable. In some areas, the public shows strong interest, in others, little. Such a situation contests the organization's degree of local presence. A maturing technological medium mandates maintaining a responsive posture for new developments that are cost effective and

efficient. Finally, the growing client demand for value requires unprecedented intimacy. Discovering and fulfilling client needs are eternal challenges.

Our following discussions shall attempt to "build" the remediation organization of the future. First, we shall further examine sustainability and decentralization and discuss necessary qualities for future organizations which is followed by a discussion of significant realities of the remediation environment. Next, I introduce possible organizational forms that incorporate elements of decentralist philosophy, and finally, I describe a future remediation organization, highlighting its purpose, structure, management, and culture.

6.2 Sustainable Development and Decentralization: The Philosophy

The value of these two paradigms stretches far beyond the simple advantages they offer for both ecological and business management. Rather, both are philosophies in their own right. The essential message of sustainable development is its proclamation of the necessity of investment in our collective future. Perhaps, an excerpt from the *Environmental Business Journal* indicates its essence:

> *Facilitating a culture change from resistance and reactive environmental tactics to a corporate strategy of environmental and resource efficiency involves a commitment to investment in the future.*

Sustainable development insures continuity in our endeavors; our lives, work, and values become linked to our past and future. It guarantees our legacy and the responsible creation of it; it views time as a cycle rather than a sequence; time circles repeatedly whether we are present for its re-entry or not. Each subsequent generation will, in some capacity, meet the same challenges and opportunities we have. Today, many of us are skeptical of the future success of humanity; I know, at times, I am. I recall the words of an ancient philosopher who proclaimed the next generation was doomed, so we are arrogant to think that our problems are unique or monumental. Sustainable development, however, is a *monumental* realization by the *whole* of society that we are all a part of something greater than ourselves, and we all have a responsibility to safeguard our resources, our world for our descendants.

Similarly, decentralization is more than just a business management paradigm that supports minimalist control and fringe autonomy. It becomes a mandate for the creation of trust and cooperation. For a decentralized organization and world to succeed, we all must willingly share and communicate with each other. In addition, traditional authority figures must entrust fringe elements with decision-making responsibility, no easy task. In the future, information availability must become unprecedented. Today, our technologies

are upon the verge of allowing such integration, but our own societal biases and prejudices block efficient interaction amongst us. We remain a skeptical world. I am continuously amazed at the lack of conversation and cordiality on my daily bus trips to and from school although the crowd is consistent. Each passenger is a compartment to himself and personal contact only occurs among prior acquaintances. If we hope to exact the fullest advantages offered by decentralization--flexibility, autonomy, equality--then we must create environments of trust and cooperation. Without this, a liberated, networked world is only a deviant of the controlled, linear world that exists today.

In the following segments of this section, I introduce several qualities that I think are necessary for a future organization. Of course, these are not original thoughts, but I borrow them from Axelrod, Handy, Peters, and Schumacher whom I am privileged to have read. While this list is not all encompassing, I expect these qualities are the most significant. I imagine they might appear alarming to some, refreshing to others. No matter, I hope their introduction challenges the most near-sighted of us to rethink his notion of business and organization.

6.2.1 Continuity

Charles Handy describes continuity, a similar message to sustainable development, as cathedral philosophy, "the thinking behind the people who designed and built the great cathedrals, knowing that they would never live long enough to see them finished."[74] We might all live more wholly with such a perspective. An individual living continuously sees her endeavors as an investment in the future. Continuous living balances self-interest with common-interest. There is no invisible hand guiding self-interest toward common-interest; rather, continuity requires a conscious realization that our individual agendas must balance with the whole's agenda. Some might argue against this philosophy. I do not intend to belabor it, but our world today is the result of invisible hand thinking, and I am displeased with its result. While wealth accumulation is dramatic, its distribution is obscene. According to a 1992 study by the US Congressional Budget Office, personal income increased by $740 billion between 1977 and 1989, but two-thirds of this total went to only 660,000 families, only 1% of the US population. Their average income rose by 77% from $315,000 to $560,000. Our middle class incomes increased by only 4%, and amazingly incomes of 40% of our population were actually worse in 1989 than in 1977. Further, the top 10% of American workers are paid six times more than the bottom 10%.[75] We have

[74]Handy, C. The Age of Paradox. Boston: Harvard Business School Press, 1994, p. 251.
[75]Ibid., p. 24.

increasingly become a society of have and have nots. Now, I am not arguing against capitalism. History has shown it the most efficient economic form, but its future requires redirection. Our future organizations cannot allow profits or shareholders total domination.

Continuity requires radically different thinking from that of today's organization. CEO's are rarely accountable to anyone other than the shareholders or the almighty dollar. Most supporters of our current form of capitalism would argue that the shareholders represent the views of society, and the organization in turn responds to the views its shareholders hold most dear. This is pure fallacy. First, the majority of today's shareholders are detached investors. Their monies are managed by brokerage houses or mutual fund accountants who have no direct interest in the organization other than its profitability. Second, shareholders are generally short-term investors, hoping for maximum return as quickly as possible, so organizational leaders naturally respond through short-term measures to produce profits. Finally, Handy describes today's shareholders as "punters". Since they are not locked into the organization, they can, in effect, "punt" whenever the environment does not favor their interests. Our current system of detached, short-term investors allows the promotion of only self-interest. I find it difficult to discover any common-interest in this form of capitalism.

Now, is it fair to expect an organization to adopt a more comprehensive agenda without a societal economic shift? I hope the answer is yes. We cannot afford to wait for our government or society to lead the revolution. Yes, an American organization truly interested in continuity is revolutionary, yet I am confident that with only moderate effort an organization might achieve this objective. The twinkling of continuity's message is evident in sustainable development, and our previous discussions highlight its approach. Shall American industry stand by and await its forced entry or shall it lead its direction? One might argue that I am contradicting myself in this argument for continuity. A pure decentralized world should allow each individual to make his/her own decisions. True, but some measure of commonality is necessary. Without common ground, the network results in anarchy. While I am not naive enough to expect individuals to balance their own interests with the common-interest, I hope we might skew the balance away from the individual and toward the whole through continuous living.

6.2.2 Connection

As my daily bus trips confirm, we have increasingly become a compartmental society. Not only is conversation absent from my bus, but often its passengers "lose" themselves in

their walkman or book. They are oblivious to their surroundings, and I often wonder how they make their stop at all. Although we all share the common, daily experience of mass transit and live in the same neighborhoods, we are not a community. We fail to connect, and I am just as guilty of detaching myself as the next. Handy describes the danger in this absence of connection:

> *It is no longer clear where we connect or to what we belong. If, however, we belong to nothing, the point of striving is hard to see. More crucially perhaps, if we belong to nothing, there is no reason to make sacrifices for other people.*

The evolving patterns of employment do not champion connection in the future. Recent television ads proclaim that millions of Americans will work from their homes in the coming years. Indeed, company reorganizations and subsequent downsizings have sent millions elsewhere. For example, General Electric has shed 200,000 employees since 1981, and IBM has reduced its workforce from 406,000 in 1985 to 256,000.[76] Bridges argues that a "job" as we know it today will not exist in the next century:

> *The modern world is on the verge of another huge leap in creativity and productivity, but the job is not going to be a part of tomorrow's economic reality. There still is and will always be enormous amounts of work to do, but it is not going to be contained in the familiar envelope we call jobs. In fact, many organizations are today well along the path toward being "de-jobbed."*

Future organizations may resemble project teams where participants are arranged on a temporary basis to complete a task. Upon completion, the team disbands and the participants search for another project requiring their skillset. Further advances in information technologies will allow designers to interact without co-location as synchronous tools become more sophisticated and prevalent. Such a reality frightens many of us; I know I'm not totally comfortable with the idea myself. The temporary nature of future work arrangements is more uncertain and unstable than the work environments of today. In addition, individual "companies" threaten the connection that the workplace now provides. Throughout this century, our workplace has been the mainstay of social interaction for most. Our organization has been our community. What will become of society when this connection diminishes. How do we provide this connection that seems a precursor for continuity?

Future organizations might act as membership clubs where its facilities support social contact rather than business activity. Offices become dens for interaction, and our dwellings house our business artifacts. Connection is facilitated by different mediums of

---

[76]Anonymous. "A Master Class in Radical Change", Fortune. December 13, 1993, p. 82; and Kiechel, W. "A Manager's Career in the New Economy", Fortune, April 4, 1994, p. 68.

social activity associated with the workplace. Today, we find the common coffee pot or water fountain; tomorrow, we discover activities or events. Perhaps, we might find lessons for enhancing connection from present day companies. L.L. Bean, an organization which provides clothing by mail order sales, has a rather interesting policy regarding outdoor experience. One of its corporate priorities is to increase its employee's and customer's awareness and appreciation of outdoor experiences. The company sponsors an Outdoor Experience Program for its employees; on a voluntary basis, employees may take 3-5 outdoor experience days per year. Some trips--biking through Acadia National Park, winter camping, kayaking along the Maine coast--are pre-organized and lead by Bean employees where those interested sign up. Employees may arrange their own trips subject to company approval and Bean employee participation. Aside from increasing their awareness, Bean hopes the experiences provide teambuilding benefits. This program is so important that during Bean's recent venture into the Japanese market it was part of the contract for Japanese franchises. Bean offers similar programs for its customers. Tomorrow's organization may, in fact, become loose consortiums of people who gather for social interaction, information exchange, and project arrangement. A thought for providing connection of individual parts to a whole is the type of program offered by L.L. Bean. Again, these thoughts may appear revolutionary, but for continuity's sake, connection is paramount.

6.2.3 Trust and Cooperation

It was not by accident that I chose to discuss an informal gatekeeper network as an alternative for tech transfer in chapter five. Instead of opting for a centralized and controlled communication medium, I am in favor of an uncontrolled network, that is alive in itself, with interactions throughout. Some branches are inert while others are living. They rely upon one another rather than a central mechanism, and the means for the network's success is reciprocity. Axelrod conducted interesting experiments in the 1980s testing the bounds of cooperative environments. He conducted computer tournaments using the Prisoner's Dilemma exercise as a means for testing entrant decision rules. In the exercise, two "players" are given the opportunity to not cooperate or to cooperate with the other on any given iteration. If they both cooperate they receive a payoff of three; if neither cooperates they receive a payoff of one; and if one does not cooperate and the other does the defector receives five and the other receives zero. Axelrod conducted two computer tournaments, and both were won by a decision rule called TIT FOR TAT that cooperated on the first iteration then in subsequent iterations responded with whatever the

other player did on the previous iteration. Axelrod described TIT FOR TAT as *nice*, *retaliatory*, *forgiving*, and *clear*. Nice means that the rule was never the first not to cooperate; retaliatory signifies that the rule did not cooperate on the iteration following another's defection; forgiving indicates that the rule cooperated following a single defection by another after its retaliation; and finally, clear expresses the ease which another was able to discover its decision parameters. All sorts of decision rules entered the tournament with varying degrees of sophistication, but overall TIT FOR TAT scored highest in both tournaments.

In his subsequent studies following the tournament, Axelrod discovered some interesting insights:

1. If everyone in a population is cooperating with everyone else because each is using the TIT FOR TAT strategy, no one can do better using any other strategy providing that the future casts a large enough shadow onto the present.
2. An environment of nice strategies cannot be invaded by another individual or a cluster of individuals using different strategies.
3. Cooperation can emerge even in a world of unconditional defection by invasion of a cluster of cooperative strategies.

Essentially, cooperation even between a small cluster of individuals or groups provides advantages other strategies cannot--greater long-term reward and infallibility. Given these conclusions, Axelrod also provides several recommendations for interaction participants. First, don't be envious. Often, we treat our interactions as zero-sum games; someone wins while the other loses. This is not necessarily the case, both sides can do well or poorly, and the one's standard of how well he is doing is not relative to how well the other is doing. Second, don't be the first to defect. It pays to cooperate as long as the other is cooperating. Third, reciprocate both cooperation and defection. Reciprocity is quite robust. Fourth, don't be too clever. Sophisticated rules of interaction often require inferences about another's intentions, and these assumptions are oftentimes wrong.

Aside from these recommendations for participant interaction, what can an organization do to promote cooperation? Axelrod provides five suggestions:

Enlarge the shadow of the future: Mutual cooperation can only be stable if the future is sufficiently important relative to the present. He identifies relationship durability and interaction frequency as the two principle ways of accomplishing this. Interestingly, our previous discussions of continuity and connection support such a strategy. Continuity requires emphasis upon longevity--today's actions affect future outcomes, and connection requires consistent interaction--contact is made only when a relationship develops. Future organizations must exhibit these qualities.

Change the payoffs: It is only necessary to make the long-term incentive for mutual cooperation greater than the short-term incentive for defection. Within organizations, this suggestion has tremendous implications for our forms of incentive. Interactions between functional groups or project teams will only be cooperative if a substantial payoff exists for synergy creation in the long-term. Perhaps, corporate or business unit bonuses should not come in small chunks quarterly or annually. Instead, they might come every two or five years.

Teach people to care about each other: Altruism is a motive for action. If we place value upon the welfare of another, the more likely we are to act in our mutual favor. Again, the importance of continuity and the philosophy of sustainable development are quite evident. Certainly, qualitative elements of our culture can influence the degree of altruism. I hesitate to endorse quantitative elements such as large dollar gifts to charity since the sincerity of such is difficult to ascertain. Personal acts are more often altruistic.

Teach reciprocity: Teaching the use of nice strategies based upon reciprocity helps the pupil, the community, and indirectly the teacher. Obviously, nice, reciprocal strategies provide mutual benefits for interaction between the teacher and pupil. Indirectly, the teacher receives benefit from the pupil since in future interactions reciprocity will punish those who try to exploit the pupil. Reciprocity is self-policing.

Improve recognition abilities: The ability to recognize the other player from past interactions, and to remember the relevant features of those interactions, is necessary to sustain cooperation. Fundamental for this suggestion is the ability to distinguish between cooperative bluffs and sincere ones. A gesture by another may prove shallow. Again, the importance of connection is evident.

Axelrod's studies have interesting implications for our future organization. To exact the advantages that our incredible information systems can provide, we must provide information willingly. If we expect the receiver to exploit us, we will filter and provide only cursory information. Instead of building upon the synergies between us, we diminish our potential. Information exchanges replicate the prisoner's dilemma in rather grand detail. Axelrod's conclusions manifest the creation of cooperative environments.

6.2.4 Competitive Spirit

Following the discussion of trust and cooperation, one might find it odd that I have chosen to discuss competition. When I began this endeavor of a thesis, I did not expect to discuss competition either, but as I continued my research, I began to realize that I would be foolhardy not to include it. Competition is a must. It battles complacency and

promotes innovation and improvement. Any organization must challenge its constituents to succeed; it needs a competitive spirit. Peters boldly exclaims, "Scientific and economic progress are products of destructive competition. Period." Beyond the obvious presence of competition between companies, Peters demands its presence within companies. He describes the early battles for efficiency between automakers that eventually settled into sluggish practices. Fortunately (perhaps unfortunately, depending upon your perspective), outsiders awoke the slumbering American auto giants. German and Japanese competitors virtually destroyed the American industry for the betterment of US consumers. This foreign intervention sent the US industry scrambling to catch up, and only today is it regaining some measure of its former position. Yet, how can an organization avoid such a dilemma? Further, how does it balance a cooperative environment with a competitive one?

Again borrowing from Peters, he recommends several strategies to sustain a competitive spirit that are applicable to our discussion:

- Destroy your most profitable products.
- Insist that every element of the firm demonstrate a "fitness to compete" by selling a substantial share of their products or services to the outside world.
- Force "fitness to compete" among support functions by allowing--and even encouraging--close-to-the-market units to purchase any and all goods and services from outside vendors.
- Subcontract extensively.

Obviously, a few of these tenets are "old-hat" in the construction industry. Subcontracting and relying upon local markets to provide goods and services are commonplace, but how many estimating groups sell their expertise independently of the construction company? Further, should the group invite queries from interested parties into their estimating database? Sound crazy, maybe so, but I hope to challenge your sense of equilibrium. Most construction firms safeguard their estimating knowledge, its a fundamental source of their competitive advantage. Allowing independent queries into it, might diffuse this knowledge, yet this certainly meets Peters' advice to destroy profitable products. Now, I am not advocating irrational action, but does such a strategy warrant merit? Possibly.

Another significant element of Peters' recommendations is the absence of any hint they might induce infighting or politics. Generally, his methods for competitive maintenance focus upon external measures. Through external market interactions, the company is forced to improve, and it receives a broader spectrum for reference. Additionally, this continues to allow the creation of cooperation and trust within the workplace. Of course, I could extol the virtues of proper incentive structures here to continue this discussion of

balancing cooperation and competition (we'll discuss this later), but I prefer to present an example of Peters' approach. Recently at MIT, I had the pleasure of attending a lecture presented by Rick Gorski and Jack Wiseman of McDermott International, Inc. about their over $12 billion venture in Russia to develop the Sakhalin Islands' oil and gas resources. During their presentation, they discussed the negotiated Russian content of the project (70%), but this content was subject to acceptable cost, quality, and schedule. Generally, Russian contractors fall far below international standards in the mentioned areas, so as part of their strategy, McDermott is visiting multiple Russian contractors, encouraging them to upgrade their capabilities. How wonderfully this situation demonstrates Peters' agenda. During the reign of the Soviet Union, the contractors had no incentive for providing anything but the minimal standards since true competition was absent, and the Russian economy was self-contained. Russia was rather sluggish. As it transitions to a market system, it must look beyond its own walls to find its competitive spirit. Russia-internal has no force of improvement or broad spectrum of reference. Obviously, any Russian contractor is interested in the influx of foreign monies (especially American or Japanese), and to receive them, they must search beyond themselves to acquire a competitive position.

6.2.5 Diversity

To enhance the spectrum of reference, an organization must value diversity, not only among its workforce, but also among its ideas and beliefs. From an organization's people spring the sources of innovation and tranquility, destruction and improvement, cooperation and competition. The previous pairs seem paradoxical, yet the tension between them, I argue, provides wonderful results. If an organization is becoming to comfortable with itself, it needs some "shaking up". F.A. Hayek, an economist and historian, espouses a few propositions that encourage diversity. He argues that liberty/wealth is due to "extended order", i.e. producers and consumers are not known to each other, the "extended order" is based upon a few overarching rules, and following a few uniform, impersonal rules maximizes variety. Variety in turn is the key to discovery and hence the creation of wealth.[77] Following this simple philosophy, we might understand better how to maximize diversity. Hayek suggests that the rules are not the result of design; instead, they evolved through interaction among members of the network. Accordingly, we might use a minimalist approach to policy and guidelines, instituting only

[77]Summarized by Peters in Liberation Management, p. 501.

those core principles that are relevant to and proven for our experience. Handy proposes a similar concept in his "inside-out doughnut"; at its core, are a set of fundamental beliefs or values, and these values establish relevant boundaries (the edges of the doughnut). The composition of the rest of it is up to each individual or group. Establishing the fundamental values is a dubious challenge, so we might incorporate Hayek's advice and allow them to evolve over time. Only then can we fully assure ourselves that they are absent of prejudice or bias, the stiflers of diversity.

6.2.6 Congruent Values

I think there is a tendency for natural progression; our organization's people are originally referenced as personnel or human resources, quickly they degrade to labor, and finally, they become costs. Not surprisingly, we desire to minimize costs in an organization, and our people become targets for reduction not growth. Our reference to people as labor biases our perception of them. No wonder employers can easily make decisions about "labor" without regard for their welfare. Similarly, employees are just as guilty as their employers. It seems no accident that employment is referred to as "work"; just as "labor" biases our perception, so does our reference to employment. How often do we associate "work" with positive thoughts? It is an invasion of our leisure and comfort. Schumacher describes the phenomenon of this culture:

> *Hence the ideal point of view of the employer is to have output without employees, and the ideal from the point of view of the employee is to have income without employment.*

This extreme situation demonstrates an incongruent fit between organizational and individual values, so how might we alter such destructive tension? Chatman studied the relationships between individual values and organizational culture. Generally, he found that individual job satisfaction and performance are higher, and the organization is more successful when a congruent fit exists between the two. On the other hand, when a dissonant fit exists (the situation above), tension is the result, and individuals attempt to reduce this tension in three general ways: 1) individuals behave in ways inconsistent with their own personal values; 2) individuals exert influence on organizational characteristics in an attempt to alter the organization and align it with their own values; or 3) individuals leave the organization. Clearly, the importance of this congruent fit is important to an organization's overall success.

In light of the previous qualities discussed--continuity, connection, trust and cooperation, competitive spirit, diversity--creating a culture that supports them is a unique

challenge. Further, attracting and employing people who match is just as daunting a task. From my perspective, people interested in such organizational qualities are rather ambitious. They desire challenge and opportunities for professional and personal growth. I suggest radical investment in creating organizations and culture that allow this. Often employers, however, fear losing people to others, hence the investment in the individual is wasted. Subsequently, opportunities for individual growth and development become rare. Individual growth and development extend beyond opportunities for education advancement and responsibility increase. They also include sensible organizational structures and management that challenge and care for people. Now, caring for people does not suggest coddling them. There is no room for subpar performers or "fat" organizational designs where five people do the chore of two. While in the Army, my definition of care for soldiers included insuring their survivability in combat. Similarly, we must prepare our people for success as well as making substantial allowances for their personal needs. Accordingly, we must dare to create efficient but rigorous organizations. I hope to demonstrate that the people of organizations are not commodities or resources; *they are the organization*, thus creating a culture that supports congruent values is an enormous task. A start might include semantic changes in forms of reference within an organization. As I previously suggested, "labor" and "work" carry negative associations with them, but titles and reference are only a small part of organizational culture. Perhaps, Schumacher provides us our cultural guide in his thoughts on Buddhist economics:

> *The Buddhist point of view takes the function of work to be at least threefold: to give a man a chance to utilize and develop his faculties; to enable him to overcome his ego-centredness by joining with other people in a common task; and to bring forth the goods and services needed for a becoming existence.*

Later in this chapter, we will further explore the culture of a future organization and hope to present some recommendations for its creation.

6.3 Remediation Realities

Until this point in the chapter, one might consider my thoughts more akin to Hamel and Prahalad's perspective of vision--a dream or an apparition--rather than foresight--deep insights into trends--but I hoped to this point to challenge traditional thoughts about the purpose of business and organizations while speaking to the underlying messages of sustainability and decentralization. Yet, I hope to act more as a prophet and not a dreamer, so I cannot ignore the reality of the remediation industry in my projection of a future remediation organization. The remainder of this section will explore four

fundamental issues raised during our discussions in chapters three through five: *industry consolidation*, *risk communication*, *demonstrating value in services*, and *technological innovation*.

At first, I considered the trend toward *industry consolidation* as contradicting the external edicts of decentralization. In some regards, it is. Generally, full service firms have gained the massive DOD contracts, and the size of the awards allows the emergence of "pseudo-industry" leaders ("pseudo" since fragmentation remains substantial). A full service firm is somewhat counter to the networked, subcontracting philosophy prescribed by Peters and the like, but analytical services, technology vendors, and specialty subcontractors remain a large part of the remediation business. Obviously, the external edicts of decentralization remain applicable. Regardless of the external situation, the internal edicts are still paramount for continued success. Regulatory influence is predominant in remediation markets, and the rising importance of local and state influence upon the process require flexibility. Projects in California are handled differently than those in Florida, and the increasing importance of risk communication in local communities warrants local understanding and involvement. Further, the expected shift in demand from cleanup to containment services as public policies change requires a keenly responsive posture. Additionally, as international opportunities develop for remediation, global resources with a local presence have proven successful for giants like ABB.[78] Indeed, such situations support the necessity of fringe maximization and autonomy.

Through my studies of US hazardous waste remediation organizations, I discovered that they had become quite adept at risk management, but not *risk communication*. Some had taken limited roles in risk communication and public involvement efforts, but others hoped to avoid any part in such endeavors. Should remediation organizations participate in risk communication and public involvement? If so, how? I fear those who tend to avoid involvement might find trouble in the near future as contractors building our nation's freeway and interstate highway systems did in the middle of this century. In 1966 for example, the San Franciscan community stopped the development of a freeway planned through the city.[79] A better community relations plan may have prevented such an occurrence. Not surprisingly, risk communication for remediation projects has proven difficult for even those experienced in it (recall our previous discussions of the New Bedford Harbor project where a small but organized community group stopped the

---

[78]Taylor, W. "The Logic of Global Business: an Interview with ABB's Percy Barnevik", Harvard Business Review. March-April 1991.

[79]Halprin, L. Freeways. New York: Reinhold Publishing, 1966, p. 155.

project). Accordingly, the ability to communicate with and involve the public is necessary for future remediation organizations.

As I consider the source of industry consolidation, I look past the current lag and depression of the market, caused in large part by regulatory uncertainty, as its cause. Instead, I am reminded of a comment by Bruce Laswell, Group Senior Vice President of Environment & Energy, ICF Kaiser, during a recent seminar at MIT. He considers future market success in remediation lies in convincing a client that their cleanup project is not an unnecessary expenditure but an investment in a relationship. Remediation opportunities, no matter how grand they apparently seem, are finite, especially as waste minimization, pollution prevention, and sustainable development become the future of ecological management. Perhaps, relationship investment is only a potential marketing strategy for a full service company. As remediation opportunities dwindle, ecological service opportunities shift toward resource management. The April 1994 edition of the *Environmental Business Journal* forecasts that by the year 2010 almost 50% of the revenues in the ecological industry will come from resource management services. A full service remediation firm can certainly more easily diversify into resource management than say a sole service remediation contractor. Simply put, a full service firm can *demonstrate its value* as a relationship investment, since long-term service is possible, markedly better than a sole service contractor can.

Finally, *technological innovation* remains fraught with difficulty in remediation. The combinatory effects of regulatory, communication and financial barriers make technology commercialization a risky enterprise. As discussed, the demand for future technology services is uncertain. Possible policy shifts require responsive posturing. Remediation organizations must remain flexible for success in the next century.

6.4 Organizational Forms

Certainly, numerous models exist for organizational design. In this section of the chapter, we shall look more closely at two organizational forms described by Handy and Galbraith: the federalist organization and the lateral organization. Handy's description is rather abstract providing basic tenets for organization rather than suggesting formal structures for consideration. Galbraith's description is more concrete, and he provides several alternative structures for facilitating lateral coordination. Following their description, I shall describe the structure of two remediation organizations I studied: GZA Remediation and Perland Environmental Technologies, Inc.

6.4.1 The Federalist Organization

Handy adopted a longstanding form of political government as a model for his organizational form. Normally, we associate federalism with countries, but his description of its strengths match possible organizational objectives in the future quite well:

> *Federalism seeks to be both big in some things and small in others, to be centralized in some respects and decentralized in others. It aims to be local in its appeal and in many of its decisions, but national or even global in its scope. It endeavors to maximize independence, provided that there is necessary interdependence; to encourage difference, but within limits; it needs to maintain a strong center, but one devoted to the service of the parts.*

Certainly, such an organization exudes the qualities we discussed in the initial sections of this chapter, yet creating it is a monumental endeavor. Handy suggests the difficulty resides in our inability to relinquish control. Federalism requires fringe autonomy, and it can prove messy or chaotic. Historically, few pure examples of federalist countries exist. Some might argue that the United States is the best example of a federalist country, and this may be true. Still, the 1994 Congressional elections indicated that the American people fear the increasing interdiction of government in their lives. The Republican coup signaled not a disparity in values between the Democrats and the public but a disparity in the role government should have in their lives. The perception is Democrats equal "big" government, and the Republicans now have the mandate from the American people to "back off". Our form of federalist government appears to have worn into an "elected monarchy" where federal officials consistently demonstrate their power and influence (recall Jefferson's thoughts from the chapter's prelude). So how can a federalist organization work?

Handy describes two qualities necessary to affect this organization: twin citizenship and subsidiarity. Twin citizenship implies dual loyalties, to a part and to the whole. With some thought, each of us might identify our own dualities; *I'm a Georgian and an American* or *I'm an MIT graduate but always a West Pointer*. As I conducted this exercise myself, I discovered how difficult it was to discover dualities beyond traditional state-country relationships. Perhaps, this suggests how difficult establishing true dualities is. As Handy points out, the local citizenship is the easy part. The challenge lies in extending this loyalty to a whole or larger citizenship. Often acquiring second citizenship is attempted through symbolic representations such as a common flag, a logo or a uniform. For example, the Army's dress green uniform is a study in federalism. Parts of it are common to everyone: the wear of rank and insignia, the colors, the standards of

appearance; while parts of it are dependent upon locale: the unit crest and patch, caps or berets. Upon closer examination, the uniform also represents how difficult establishing duality can prove. Generally, soldiers are members of a battalion, a division, and the Army. They wear separate battalion crests and divisional patches, so where does their loyalty lie? Are they members of the third engineer battalion and the 24th Infantry Division or are they members of the 24th Infantry Division and the US Army. Members of the 82nd Airborne Division wear distinctive berets, so one loyalty is somewhat certain. Still, where is their second loyalty?

I suggest symbolic representations have limited potential for loyalty creation. Handy describes an alternative approach where top leaders infiltrate the organization to communicate and represent the whole to the parts. He discusses Roosevelt's fireside radio-talks, Churchill's wartime broadcasts, and Clinton's town meetings as forms of such an approach, but he questions their potential for sustained second citizenship. Certainly, it seems difficult to underplay the significance of efforts like Churchill's where he almost single-handedly rallied a nation for a common cause, but I contend that second citizenship only manifests itself through valuable human experience from being part of a whole. I question tangible representations of value such as money or benefits. Tangible assets can be discovered elsewhere; another organization can always offer additional money or vacation. Second citizenship evolves from intangible forms of value; challenge, autonomy, growth, equality, comraderie. This sort of value is difficult to provide or create, and possibly why so few dual citizenships exist.

Handy's second quality is subsidiarity, reverse delegation or delegating by the parts to the center. It appears a perplexing concept and rather to attempt to explain it myself, I'll borrow Handy's description:

> *Federal organizations take subsidiarity seriously. They have to because they work on the principle of reverse delegation. The individual parts, or states, cede some of their powers to the center because they believe that the center can do some things better on a collective basis. Therefore, they retain as much independence as they think they can handle.*

This idea has interesting implications for the form of organization and leadership. It strongly supports discovering the core responsibilities of the larger organization and structuring the core to perform them. Recalling Xerox's reorganization from chapter two, a core headquarters and research and development group were created to support several autonomous business units. Their responsibility became supporting the business unit requirements and providing holistic systems such as distribution.

While Xerox expended substantial resources in designing their new organization, John Seely Brown (a principle architect of the new Xerox) commented this was the easy part; the difficulty became redefining the organization's and its leaders perception of itself. The redesigned company required a different sort of leadership and mindset than the old one. "New" Xerox required shared understanding, cooperation, communication, and initiative. Unfortunately, the organizational leaders reverted to previous methods of management where protecting and promulgating their group or functional unit was prolific. Leaders were quite unwilling to relinquish control or resources for others' use. The autonomous units were unwilling to cede resources to the whole for the good of the whole.[80] Federalist leadership becomes facilitation rather than direction, delegation rather than control.

6.4.2 The Lateral Organization

Departing from the abstract organizational form just described, Galbraith provides a more systematic discussion of a lateral organization. He argues that the motivation for lateral organization arises from the need for lateral coordination since some activities require coordination across the ranks not through a hierarchy. The introductory chapter presented several forces, including diversity and work interdependence, identified by Galbraith that are driving the need for lateral coordination at the business unit level. As we transition into the era of the consumer where generic products become less attractive, flexibility, product diversity, and time to market become more significant organizational capabilities. Beyond lateral coordination requirements within a business unit, he identifies forces that are driving corporate and international coordination. Increasingly, corporations are competing upon capabilities that are distributed among business units. As they continue to search for ways of adding value, it no longer resides within corporate staffs, but within the business units themselves; hence lateral coordination requirements. Internationally, global integration and global dispersion are increasing corporate needs for lateral coordination. The degree of each is dependent upon the business and country, but the greater the degree, the more intense the lateral coordination. He argues that it is unlikely that hierarchical organizations can handle these situations; lateral organizations are necessary.

---

[80]Details from: Seely Brown, J. Lecture delivered at MIT via video conference on September 21, 1994.

We shall examine four forms of lateral organization discussed by Galbraith: the informal organization, the formal lateral group organization, the integrating organization, and the distributed organization.

The Informal Organization - Lateral coordination is achieved through voluntary interactions between individuals in various functional units. Generally, no formal organizational design or reinvention creates this but rather discrete strategies for enhancing organizational interaction accomplish it. Galbraith describes methods such as interdepartmental rotation, physical co-location, information technology networks, interdepartmental events, mirror-image organizational structures, and consistent reward and measurement practices. Such strategies are commonplace, and the availability and capabilities of IT networks makes them a prevalent choice. Stories abound about e-mail networks that "magically" transform communication environments within organizations. This approach is the least difficult and most timely.

The Formal Lateral Group Organization - This design is a conscientious effort by an organization to affect lateral coordination. Teams are formed by design, not voluntarily. As such, more effort is necessary for team development and resourcing. Representatives from different functional groups coordinate and communicate with representatives from other groups. These groups can exist within a network or hierarchically. Galbraith describes a hierarchy of design/build teams within Boeing's 777 program.[81] The top team approves the preliminary design, sets parameters for the overall plan, creates criteria for team decision-making, and resolves conflicts that the lower teams cannot. The bottom teams perform the activities necessary for the task and coordinate with each other where necessary. Boeing's groups are multidimensional, functional, and hierarchical. Clearly, this is a rather complex example of formal group organization.

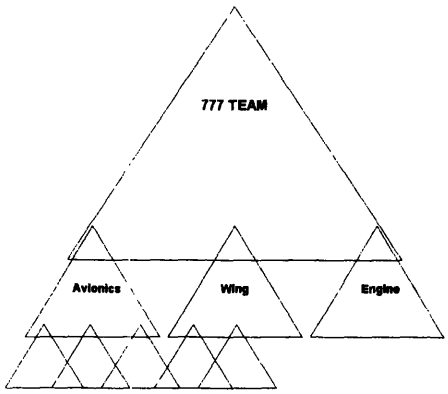

Figure 8. Formal Lateral Groups

The Integrating Organization - Integrating roles are implemented when the sheer volume of additional decisions to coordinate diverse units requires substantial general management capacity, when exhaustive boundary-spanning is necessary since organizational units are so diverse, or when an organization has multidimensional strategies, thus requiring multidimensional structures. Integrators are normally titled as product, account, or project managers. The integrator resolves conflicts, filters and communicates information, and monitors parameters or boundaries. Today, "expert"

[81]This figure is adopted from Galbraith; it is not a complete representation of Boeing's team since it is only intended to demonstrate a formal group organization.

information systems can perform most of these functions, so they are replacing humans as integrators in some cases. Still, the integration role remains necessary for many organizations.

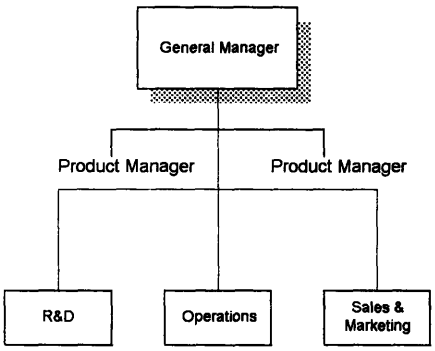

Figure 9. Integrating Roles

The Distributed Organization - This organizational form distributes roles and responsibilities normally assumed by an headquarters staff throughout operating units in the organization. It makes operating units responsible for particular activities or functions; the units also become accountable for some measure of the organization-wide mission. Often this organizational form is adopted when local expertise becomes superior to central expertise. It attempts to avoid the loss of urgency and touch frequently associated with central support functions while capitalizing upon the advantages of local presence. Further, the additional responsibilities might motivate local organizations from this display of confidence in their abilities. An inherent danger in such a strategy is the loss of neutrality and company-wide view otherwise granted by a central support staff. Corporate models normally either distribute staffs or develop centers of competency. Distributed staff models may place, for instance, corporate training responsibilities with the corporation's unit with the best training program or hiring with the best hiring unit. Centers of competency is a similar concept except unit's become accountable for a corporate capability. Usually, units with the most advanced or sophisticated capabilities are designated 'centers of competency'. Business unit models are akin to their corporate counterparts except business functions are distributed. One unit might perform computer-aided design and other units are linked to it using information systems. Galbraith identifies balance of power and reciprocity as fundamental elements for a distributed organization's success.

6.4.3 Example Remediation Organizations

I examined the current structures of two remediation organizations: GZA Remediation and Perland Environmental Technologies, Inc. While I found evidence of lateral organization efforts as described by Galbraith, each firm remains functionally organized. Project teams are formed by temporary assignment of functional department representatives for a project's duration. GZA Remediation (GZAR) is a subsidiary of GZA GeoEnvironmental Technologies, Inc. (GZA). GZA is a multidisciplinary environmental/geotechnical consulting and remedial construction firm that provides environmental, groundwater, geotechnical, and instrumentation engineering services;

comprehensive remedial design; treatment systems fabrication, installation, and operation; and complete test drilling services. GZAR provides the remedial design, treatment system, construction management, and UST services. GZAR has several district offices supported by a central support staff with evidence of integrating roles present. At the business unit level, the district offices have functional groups, and group members ally for projects as necessary. Project administration is handled by a project manager with support from in-house staff. Project field services are directed by field engineers whose primary responsibilities are the coordination and management of the various subcontractors. In addition to their services, GZAR maintains comprehensive programs of risk management and health and safety. In 1993, GZA's corporate revenues were nearly $43 million with a net income of $1.7 million.

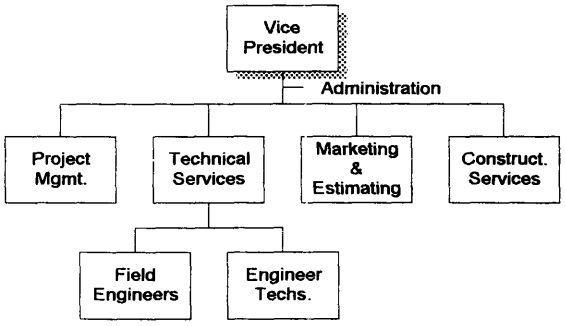

Figure 10. District Office Structure

Perland Environmental Technologies, Inc. is a wholly-owned subsidiary of the Perini Corporation. Perland provides remedial engineering and construction services nationwide, primarily on a full-service basis, for hazardous material management and environmental restoration. The company has two major goals: first, to restore the environment through strong project management and construction; and second, to focus on cost by preparing detailed construction cost estimates to identify cost drivers and high risk activities. Alternative methods are considered for high cost and risk activities. As is GZAR, Perland is functionally organized but project teams are formed where a site project manager from the construction group directs a site operations manager (construction) and a site controller (financial control). The site project manager also works with a site health/safety officer and a quality control officer (both from engineering).

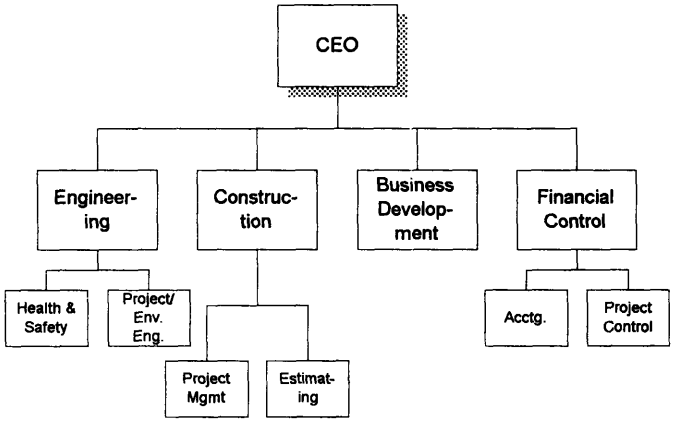

Figure 11. Perland Structure

6.5 A Future Remediation Organization

In this section of the chapter, I hope to build upon the topics discussed previously to provide a rather abstract form of a future remediation organization. I shall attempt to create a model for a national remediation corporation that might exist a decade into the 21st century. Certainly, to fully design an organization would require substantially more elaboration than I will provide. I hope, however, to suggest a basic roadmap for the organization. I generally use elements of Hammer and Champy's business system diamond as a guide for this discussion. I will suggest the organization's purpose, its structure and jobs, its management and measurement, and its culture.

6.5.1 Purpose

At the heart of an organization is its purpose. Today's theorists harp upon the core's importance writing about core competencies where reside the organization's competitive posture in today's variable and global business environment. From its purpose springs the complementary elements of the organization. Until it is defined, we cannot discuss any other aspect. We cannot determine whether the trends toward "virtual" organization or subcontracting are appropriate. We do not know whether to complement our competencies vertically or horizontally. Accordingly, establishing an organization's purpose is a prelude for success or failure. Yet, what is our definition of success? As I describe organizational purpose, my definition will become implicitly evident. My discussion of purpose will center upon two criteria: competency and accountability.

I shall discuss competency from two perspectives: first, the breadth of services and second, the type of services. Market trends indicate the necessity of full service capabilities as more and more turnkey projects become available. Generally, the major, prime contract awards have gone to full service firms. Some prime contract awards have been granted to an engineering and construction team, but to a lesser extent. Still, the volume of the contract awards has required even full service firms to team with other firms on occasion. Beyond current market activity, the forecasts of increasing client demands for value require innovative thinking beyond today's marketing activities; all the firms I studied claimed to offer value engineering in their services--their solutions are "efficient" or "cost-effective". Differentiation requires offering qualities others cannot, and the market is saturated with value engineering approaches. As discussed previously, marketing a relationship is a possible alternative. Clearly, remediation clients want to limit their opportunities for providing revenue to contractors. In addition, the number of sites

requiring cleanup is unlikely to grow substantially with the emphasis upon resource management and pollution prevention. Subsequently, sole service providers are in a difficult position for a sustained competitive advantage. In some capacity, these market trends contradict the external edicts of decentralization--once core competencies are discovered, organizations should shed excess and subcontract to complement their core. Full service firms have quite a diverse set of skills; the cultures and practices of engineers vs. contractors are significantly different. Given this apparent contradiction, what breadth of service should a remediation organization provide?

Indeed, a full service contractor seems to have greater potential for providing a long-term relationship, but a sole service contractor would appear to have better flexibility. Clearly, the breadth of the organization's competency is relative to its goals. If longevity is unimportant, then sole service contractors can compete in the short-term. In chapter three, we discussed how some sole service contractors have teamed to receive large remediation contracts. The external edicts of decentralization are quite applicable for them. Without effective partnering and cooperation, they will struggle to find work. If, however, longevity is important, then full service providers stand to maintain a better competitive advantage. From our qualitative organizational description earlier in the chapter, longevity is apparently important. We cannot provide continuity or connection without it. Not surprisingly, our purpose must support longevity to avoid short-sighted or speculative strategies. I hesitate to grant faith in the long-term success of sole service remediation providers. Certainly, cleanup opportunities will remain far into the next century, but their prevalence will dwindle. I expect a full service provider can flex into other dimensions of ecological services (i.e. resource management) more easily than a sole service one, thus the ability to sell a relationship. If our goal is longevity, then we must offer full remediation services.

What exactly does this mean for the organization? What type of services should it offer? Must it offer a full array of services--analytical, engineering, construction, and technology? Not necessarily. With further analysis, I suggest that the competency of the organization has less to do with the breadth and type of services offered and more to do with its inherent strength. Analysis by the *Environmental Business Journal* provides some insight. In the April 1994 edition, it comments:

> *The writing on the wall portends the transition of an industry founded on cleanup and control to one focused on process and prevention....The key advantage environmental companies possess, however, is a track record, a cumulative knowledge of their market and the experience and ability to integrate several technologies into projects or systems.*

This suggests *knowledge* rather than *facility* as the source of advantage. An experienced and knowledgeable management group can integrate facilities provided by specialists. Subcontracting can remain extensive; the key becomes knowledge of client systems, prevention processes, available technologies, and systems integration. A core group can manage and coordinate the services necessary. The core competency of the organization is its *knowledge* of systems and processes and its ability to *coordinate* and *integrate* project participants/systems to accomplish a task. An organization that cultivates and sustains such an ability can offer whatever range of services is necessary in the future remediation or ecological services industry. Supplementing the core competency are several secondary competencies that I have identified from analysis in chapters three through five: risk management and communication, organizational and community health and safety, and technological knowledge. To a lesser extent, these competencies require safeguarding and development.

Resolving that the organization's competency is knowledge of system integration and coordination that is capable of providing full services, we now turn to its accountability. Traditionally, the organization is accountable only to its clients and shareholders (providing the required attention to government regulations to avoid penalties and liabilities). I suggest a broader regime of accountability. Handy describes a hexagon contract between the organization and its accountants: financiers, employees, suppliers, customers, the ecology, and society as a whole. Certainly, some organizations have already adopted a more comprehensive purpose. Clean Harbors Environmental Services, a New England based corporation providing hazardous waste management and remediation services, has adopted six corporate priorities: health and safety, compliance, quality customer service, employee and community relations, teamwork/communication, and shareholder value. While these priorities do not exactly match Handy's recommendation, nonetheless they are fairly comprehensive. The organization measures its senior managers against these priorities and regularly conducts roundtable seminars with its top fifty managers to discuss them. Recently, their Operations Committee held meetings on methods for fuller integration of their workforce into corporate activities, and Norman Nelhuebel, Director, Remedial Technologies, commented that their goal is bottom up communication where the employees feed their ideas to corporate leaders. He believes the success of this effort is linked to reciprocity, managers and employees sharing valuable information with each other. Clearly, Clean Harbors is moving in a direction that supports the philosophy of sustainable development. Our organization shall adopt Handy's hexagon contract as its manifest, thus fulfilling the necessity of responsible legacy creation. *Thus, we define our organization's* ***purpose*** *as providing full remediation services*

through knowledge of systems integration and coordination as a comprehensively responsible and accountable organization.

6.5.2 Structure and Jobs

Building upon previous discussions, we want to create an organization capable of providing full service, thus allowing ready diversification into resource management while remaining lean and competitive. We shall take advantage of the synergy offered by the juxtaposition of the market and decentralist trends. In this section, I will create models of corporate and business unit structure as well as discuss the role of the individual. I must emphasize that these are generic models, and I do not attempt to link them with specific competitive strategies. My goal is to create a structure that will support the organizational qualities and purpose identified.

6.5.2.1 Corporate Structure

Our corporate model extracts elements of the organizational forms introduced by Handy and Galbraith. The model is federalist. A greater whole exists, but its form, the corporate staff, is lean. The corporation's primary responsibility is the support of the business units. The model is distributed. To keep the whole lean, centers of competency are established placing corporate-wide responsibilities with business units. Particular business unit competencies should include health and safety, technological monitoring, and risk management and communication. At the head of the organization is the *corporate director*, primarily responsible for safeguarding the organization's purpose, evaluating it, and altering or reinventing it as necessary. Comfort is a forerunner of complacency, so the director must remain vigilant for such signals. In the near future, the director's challenge will become the transition from cleanup into resource management services if necessary. The director is augmented by three groups: *infrastructure*, *support*, and *development*. Each group's purpose is to support the business units; they do not create or set policies, but they respond to business unit requests (a minor exception to this edict is given to the development group who

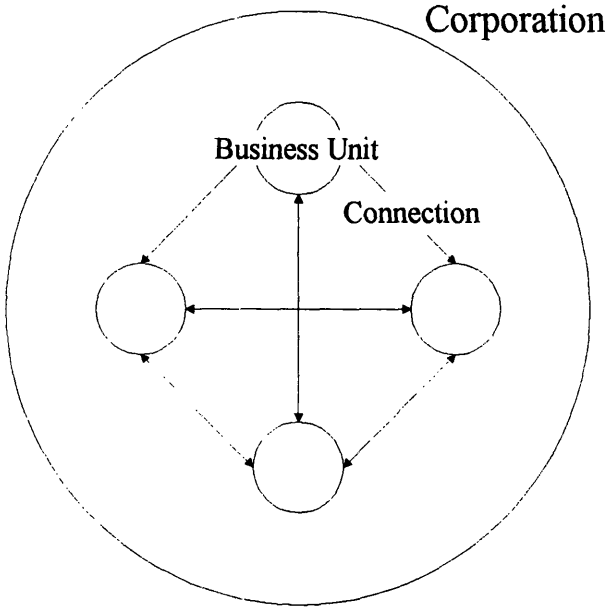

Figure 12. Corporate Model

perform a unique function that we'll discuss momentarily). Infrastructure is responsible for maintaining the **connection** between business units primarily through information system applications and assistance. As our following discussions will attest, company members will communicate using information systems rather than through intermediate managers who filter and transfer information. Accordingly, the information infrastructure is extremely important. The level of expertise in this group is dependent upon the organizational designers' preferences. I recommend maintaining a theme introduced in the previous section of this chapter: *knowledge* vs. *facility*. Acquiring and maintaining knowledge of available information systems is substantially more important than having the facility to create one. The group can subcontract information specialists as appropriate. In addition to knowledge, they must be able to *coordinate* and *integrate* the system with the existing infrastructure. Such a responsibility is quite difficult. It mandates a keen understanding of the organizational environment and culture. As such, they must be adept at receiving and responding to business unit needs. I must emphasize *their fundamental mission is to support the connection between the business units and not for the business units to support the connection*. I expect the members of this group will spend little time in the corporate headquarters and much of it amongst the business units. They must perform their role by "walking around".

The support group performs the financial accounting operations of the corporation. It manages the financial accounts, transactions, and salaries of the corporation from a central database. All members of the organization have access to view the financial information, but entry and manipulation are granted by security codes granted to appropriate individuals. The development group is responsible for the corporation's growth. Their role is twofold. One, they support business unit marketing and sales efforts as necessary. Two, and more importantly, they are harbingers of the corporation's intellectual assets. They measure the *knowledge* of the organization and upkeep its fitness. While they avoid policy creation, they must provide recommendations to the director as necessary. I feel the acquisition and maintenance of knowledge is so important for a future organization that it warrants special attention. The people of our organizations are no longer providing expertise of a particular skillset. They are system integrators assembling others' competencies for the execution of a task or project, and the quantity of peripheral knowledge required is enormous. More importantly, the core of their knowledge becomes significant. The organization needs problem solvers not engineers; it needs coordinators not managers; it needs initiative not direction. How well the development group performs will perhaps dictate the organization's longevity.

Separate business units make up the core of the organization, and their geographic distribution is subject to the environment. I do not endorse the addition of regional staffs between the corporate director and staff and the business units. An additional layer increases information filtering and decreases reaction time. If the corporate operations become too much for the director to handle, I suggest incorporating individual integrators who become responsible for monitoring operations of regional business units.

6.5.2.2 Business Unit Model

The business units are the core of the organization; they are the wheels of the corporate vehicle that fulfills the hexagon contract. Yet aside from its center of competency responsibility, it becomes a self-contained organization responsible for attracting its own business, managing its own affairs, and hiring its own people. The corporate groups are available for support, and *its sister units are also available*. We hope to encourage information exchange between business units. Affecting this sort of cooperation is difficult, but we shall address this issue in the next section of the chapter. Now, suffice it to say that the key for information exchange is reciprocity.

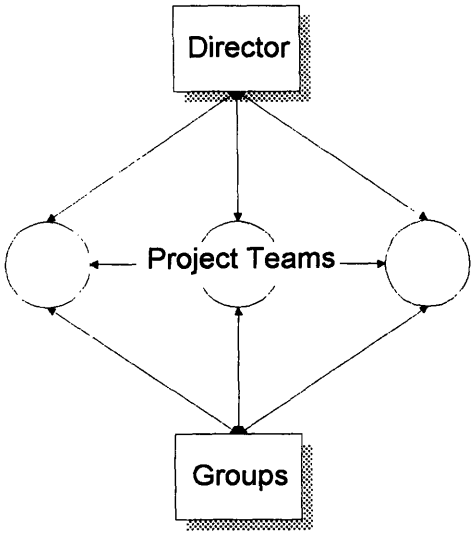

Figure 13. Business Unit Model

The head of the business unit is the *business director*. His responsibilities are quite similar to his corporate counterpart, and he is supported by matching groups. The business unit groups operate under the same mandate as their corporate brethren: SUPPORT! The business director may choose to augment his staff with an additional group to handle the corporate center of competency assignment or it might be handled as a collective effort between the support group and project teams. The "rock" of the business unit is the project team. As the business unit is self-contained, so are the project teams. They are responsible for acquiring their own clients and managing their own projects. Teams are headed by a *team director*. The team director is a facilitator and coach; she provides guidance not direction. The people who make up the project teams are *coordinators*. Team skills include communication, problem solving, coordination, and integration. The team calls upon the business unit or corporate development group to support its marketing efforts or it might subcontract. Teams within business units augment one another with information and assistance as necessary.

The business unit structure enhances the organization's competitive spirit by forcing the project teams to sell their own product; they alone are responsible for their team's success or failure. In addition, the leanness of the organization forces it to subcontract extensively to augment its capabilities, but sufficient "safety nets" are provided from the corporate and business unit support groups. The challenge is balancing subcontracting with in-house support; I expect the tendency will be to overcompensate in-house, so initially directors may want to consciously maintain a "constant hustle" in-house until the location of the fulcrum is determined. The structure requires cooperation. Inevitably, some business units or project teams will find themselves busier than others. Less busy units or teams will augment them as necessary. Synchronous information systems will allow remote assistance. Obviously, this cooperation will not evolve by itself. In fact, as described there appears to be more incentive for competition amongst the units and teams than cooperation. Our discussion of incentives and culture in later sections will address this apparent discrepancy.

6.5.2.3 Individuals

Individuals in the organization are either *directors* or *coordinators*. If necessary, we can also attach their role within the organization for further identification, i.e. team director, infrastructure coordinator, or team coordinator. I struggled with the idea of giving everyone the same title, i.e. associate, or no title at all, i.e. everyone is identified by their given name. My reasoning is simple. Our society associates titles with status; how many organization vice presidents want to discuss an important inter-company matter with another's assistant project manager? I recall an instance from my service in the Army. I was a first lieutenant filling a captain's position, assistant S-3, in our unit operations section; prior to an upcoming field exercise that I had an integral part in planning, another unit's assistant S-3, a captain, called with a question about the exercise. When I answered the call, he refused to discuss the matter with a lieutenant; he wanted to talk to our major even though I had more direct knowledge than the major (rank progression is lieutenant, captain, major). Granted the rank hierarchy in the military is somewhat magnified, nonetheless, titles promote status hierarchies that disrupt communication and cooperation. So one might ask, why did I choose any status hierarchy at all? Basically, I chose to differentiate for two reasons: first, to avoid inter-corporate or business unit difficulties in identifying organizational leaders; and second, to avoid intra-corporate or business unit difficulties in identifying organizational leaders. Leaders are still necessary, but their roles

are different from authoritarian, hierarchical approaches of today. We'll discuss this in more detail in the next section.

Individuals need talent not skill. For example, the organization needs those who can solve problems rather than engineer a specific solution. Certainly, problem solving ability is acquired through practical application in a chosen field such as mechanical or civil engineering, but we do not want those engineers who cannot apply the broader principles to a different environment or medium. Drastic specialization in one discipline can drastically limit our flexibility. Our specialty is **coordination**. The organization should look for individuals with multi-disciplinary educational backgrounds capable of transferring macro skills to different domains. Fortunately, developments in education are emphasizing this inter-domain and multidisciplinary approach such as MIT's proposed Design Studio of the Future.[82] Many may argue that a generalist knowledge is subject to wear; over time, they can lose touch with dramatic changes within specific domains. This might prove true in extreme circumstances, but our subcontracting approach should bring knowledge into the organization as long as we do not fixate upon hiring low bids. In addition, our corporate development group is charged with knowledge upkeep. Finally, talented people with broad skill sets readily adapt to changing environments.

Individuals do not need to be permanent fixtures in the organization. Recalling our discussion about connection, evolving employment patterns point toward a more "individual" workplace in the future. Team coordinators could reside elsewhere when projects are slow, and consult with the business unit as required on a per diem basis. Perhaps, the entire team could work on a per diem basis; the organization would then become the place of social interaction and knowledge transfer/upkeep as described previously. In any event, as the market ebbs and flows, individual involvement in project teams could cycle along with it.

6.5.3 Management and Measurement

With a challenging and comprehensive purpose and a rather lean structure in place, the organization's management and measurement system is challenged to make this work. Our following discussions will look in some depth at the management philosophy, the organization's direction, and management support systems. In addition, we shall examine corporate, business unit, and individual measurement systems.

---

[82]For more information contact MIT's Department of Civil and Environmental Engineering.

6.5.3.1 Management Philosophy

The tenets of management become trust and respect, cooperation, and learning. Trust is necessary to allow diversity to flourish in the organization. From diversity springs a breadth of knowledge and innovation impossible in a static environment. Organizational information is available to everyone including financial information. I recall Dee Hock, architect of Visa, describing an organization-wide meeting question and answer period when he was asked how much he earned as the organization's CEO and why he deserved this salary. He responded truthfully. What I find fascinating about this situation is not Hock's willingness to respond, but the organizational environment necessary for the question to even be asked. Clearly, such an environment promotes free thought and authentic interaction. Trust and respect allow cooperation. Cooperation is facilitated by emphasizing long-term objectives and rewards and through reciprocity. Directors must act according to and encourage the elements of TIT FOR TAT: nice, retaliatory, forgiving, and clear. Finally, knowledge is the organization's most valued asset. Through internal and external interactions, the organization can learn about itself and the outside world. Treat alternative approaches curiously rather than cynically.

These tenets place enormous pressure upon the organization's leadership. During a recent lecture by Mort Myerson, CEO and architect of Perot Systems, he pointed out two interesting conditions for future leadership:

- allowing dissension beyond the point of decision.
- creating space for authentic conversations among people.

From my own education in leadership, these are alarming perspectives. I was taught that dissension was okay until the decision point, then consensus was forced if not achieved. Myerson believes that such an approach creates false consensus and forced consensus propagates to constant consensus. Over time, dissenters learn that at some juncture, they will cease to have an opportunity to promote their position. Instead of wasting effort, they conform. Before long, decisions are easily made, comfort results, and complacency follows. Myerson's first idea of leadership supports competitive spirit. Now, he quickly points out that continued dissension does not necessarily result in a decision change, but allows challenge rather than conformity in the environment. His second idea of leadership supports the necessary trust, respect, cooperation, and diversity required for our organization. I cannot provide a formula or methodology for this form of leadership, but I suggest its essence lies in relinquishing control. Once relinquished, people find the freedom to act appropriately.

6.5.3.2 Organizational Direction

I do not intend to provide a strategic methodology or forecast the direction an organization of the future might take--the former, many more skilled and articulate than I have already done; the latter, is beyond my capacity. Instead, I hope to suggest my ideas about setting the organization's direction. Once again, they are not original thoughts, but I borrow from concepts introduced by Peters, Hock, and Seely Brown. At a meeting in 1990 with top executives from Motorola, Tom Peters was asked, "what importance would you assign to top management decision making/strategy setting in the coming years?" Peters replied none:

> *That's right: I don't believe top management should be in the business of strategy setting at all, except as creators of a general business mission. Strategies must be set from below...by the autonomous business units.*

Hock described the evolution of Visa as a transcendent effort. Its principles evolved through mass discussion and consent. Hock hoped the principles that would guide the organization were "management proof". Finally, John Seely Brown described Xerox's decision to grant the task of reinventing the organization to a group of high junior performers who were asked to design alternative organizational forms of the corporation that they wanted to inherit. Each message is clear: organizational direction is set from the fringes.

6.5.3.3 Management Support Systems

Obviously, future management support systems will be information technology intensive. Realistically, we can expect synchronous applications that allow same time and different place coordination. We can expect the technical obstacles of today such as infrastructure and bandwidth to diminish, so sophisticated graphical interface can also occur between domains. Our organization must utilize a central, sophisticated database over a wide-area network to facilitate interaction. All organizational information must reside in this database, and all members have access to at least view the information. Beyond this obvious system, the support groups at the corporate and business unit level exist solely to provide assistance to business units and project teams. For example, when a project team is preparing a proposal, they could send their ideas to a development group who could do the packaging and production necessary for a proposal. A sophisticated information system will obviously facilitate timely support of this sort.

6.5.3.4 Corporate and Business Unit Measurement

Traditionally, business has measured itself only in economic terms. Beyond the obvious reason that financial fitness is required, economic measurements are quantitative, and therefore easy to count and evaluate. The hexagon contract that is part of our purpose requires some rather qualitative measurements. For example, how should we measure our employees? Are we interested in their individual performance? Certainly, the corporation is interested in measuring the individual performance of its business unit leaders, but it cannot stop here. Since the organization's knowledge is its core competency, how do we measure knowledge acquisition? Tests? Expenditures on education? Further, if we believe that the cultivation of twin citizenship requires valuable human experience, how do we measure this with our employees?

Clearly, these are tough questions. Measuring a comprehensive accountability contract is not easy, but what follows are my ideas for measurement. Business units set their own goals subject to review by the corporate director who insures commonality and eliminates conflicts of interest. The business unit is measured relative to its financial performance, employee development, subcontractor/material supplier relations, customer satisfaction, ecological performance, and community relations. Borrowing the balanced scorecard concept introduced by Kaplan and Norton, each of these dimensions is measured relative to corporate or business unit goals. Goals and measures for financial performance are the simplest. For example, a financial goal may be quarterly growth that is measured by quarterly sales and operating income. Beyond financial measures, the task becomes more difficult. Goals for employee development might include increased awareness of technological trends, increased employee education, or simply employee satisfaction. Measures might include (respectively) the diversity of technology subcontracting or attendance at technology seminars/fairs, voluntary enrollment in part-time education programs or education/training expenditures, and retention rates or productivity figures. Perhaps, a qualitative measurement or "gut feeling" is possible as well; the level of "hustle and bustle" within the organization might signal frequent outside interaction where external perspectives are acquired (this, however, might signal other things). Similar goals can be set for subcontractor/material supplier relations and customer satisfaction, so I shall not belabor them here.

Goals for ecological performance and community relations present a unique opportunity. Ecological performance goals can be as simple as compliance with all applicable regulations or as comprehensive as the CERES principles. Obviously, I favor a more comprehensive ecological agenda, but adhering to an extensive program may be

beyond a firm's capacity. At a minimum, ecological goals should extend beyond control of pollution to reduction of it. In fact, future regulations may require such activity. Measurements would become expenditures on ecological controls and compliance, use of recycled materials, expenditures for waste disposal at construction sites, and possibly involvement in community programs. Goals might also include increasing employee awareness of outdoor experiences as L.L. Bean does today, and measurement is simply participation in voluntary or organized programs. Community relations goals might be similar such as encouraging employee involvement in community activities, creating community recreational programs or increasing awareness of our effect on the community. Measures become employee participation or program expenditures. Clearly, comprehensive accountability requires a substantial measurement effort, but with the aid of advanced information systems, gathering such information should become less of a hassle. The true barrier to such an agenda is skepticism of its value.

6.5.3.5 Individual Measurement and Incentives

As each business unit establishes its own goals, so shall each individual. Using the hexagon contract as a guide, each employee will establish their personal goals in appropriate areas. For example, a team coordinator might set a goal of a 100% match or reduction between estimated project costs and actual expenditures as a financial performance goal and to complete a correspondence course in bioremediation as a development goal. Coordinator goals are subject to review by directors. At the appropriate interval for performance evaluation, the director reviews the goals with the coordinator. Based upon the review, the director has authority to award a graduated performance bonus to the individual relative to goal achievement. Individual incentives guard against complacency and reliance upon others to pull the team through. Similarly, business directors set their goals for review and evaluation by the corporate director.

Beyond individual performance incentives, directors and coordinators receive business unit and corporate performance bonuses. The relative level of each is extremely important to our ability to establish a cooperative environment. For example, if the individual performance bonus is too high relative to the business unit performance bonus, team directors and coordinators will have little incentive to cooperate with one another. In such a situation, our hopes for achieving cooperation lie in qualitative elements of our culture. Inter-business unit cooperation will be affected similarly if the business unit bonus is too high relative to the corporate bonus. I would be foolish to think that I could predict the appropriate level for these bonuses, but the payoffs must support intra and inter business

unit cooperation. Disparity between director and coordinator bonuses should be minimal. I expect that individual performance bonuses should be relatively small and more frequent, business unit bonuses fairly substantial and a bit less frequent, and corporate bonuses quite large and occasional. This form of incentives supports cooperation by enlarging the shadow of the future through payoff.

Beyond monetary incentives, I'd like to discuss two topics: base salaries and the value of human experience. Base salaries provide a rather interesting forum for discussion. On one hand, the difference between the corporate director's salary and the most junior coordinator should not be obscene. To maintain the lack of status hierarchies, salaries must be comparable. Unfortunately, corporate and business unit salaries must be competitive with industry benchmarks if we hope to attract top performers, so this presents a difficult problem. Which is why I cannot emphasize enough the value of human experience. Recalling the discussion about twin citizenship, monetary reward is transient. Another organization can replace it with a greater reward. What another organization will have difficulty replacing is the culture and the environment of the firm. Incentives should include opportunities for individuals to grow and interact outside the business environment. I am quite intrigued with the voluntary Outdoor Experience Program at L.L. Bean. Perhaps, we can augment our corporate culture with such incentives, yet we cannot replace it. The corporate culture is the bond or glue of the organization. It provides the pure value of human experience. The next section will discuss this monumental aspect of the organization.

6.5.4 Culture

Elements of the desired culture are evident in our previous discussion, but what is this rather abstract concept of culture? Schein defines culture as:

> *a pattern of basic assumptions, invented, discovered, or developed by a given group, as it learns to cope with its problems of external adaptation and internal integration, that has worked well enough to be considered valid and, therefore is to be taught to new members as the correct way to perceive, think, and feel in relation to those problems.*

From this definition, I identify four primary influences upon culture creation: intent, time, interaction, and socialization. A culture will evolve regardless of intent to create a particular environment, so if a particular environment is intended, it requires careful consideration for its creation. This cultural evolution is not quick, so unintended or intended qualities require consistent practice and reinforcement before they become rooted

in the organization. Interaction among members of the group and with others outside the group defines the evolving culture. Finally, member socialization can either disrupt or reinforce the existing culture.

Schein defines three levels of culture: *observable artifacts*, *espoused values*, and *basic underlying assumptions*. Artifacts are evident upon entry to an organization. The interior design, dress code, and organizational titles provide ready indications of existing culture. Organizational structures, records, and products provide further examples of cultural artifacts upon keener observation. Espoused values, the second level, manifest themselves in group norms, ideologies, charters and philosophies. Corporate charters instituting particular programs of training or action offer ample evidence of organizational values. At the deepest level are the basic underlying assumptions that are the unconscious beliefs, perceptions, and thoughts that motivate behavior. Normally, deeply held assumptions begin as values that stand the test of time and gradually embed themselves into the organization, but Schein points out that it is quite possible for a group to hold conflicting values that result in inconsistent behavior while sharing underlying assumptions.

Schein identifies several mechanisms that embed a culture: where leader's pay attention, measure, and control; leader reactions to critical incidents; deliberate role modeling and coaching; operational criteria for the allocation of rewards and status; and operational criteria for recruitment, selection, promotion, retirement, and excommunication. Secondary mechanisms for articulating and reinforcing a culture are: organizational design and structure; organizational systems and procedures; the design of physical space, facades, and buildings; stories, legends, myths, and symbols; and formal statements of organizational philosophy, creeds, and charters. Further group member socialization can result constructively in either *custodial orientation*, total conformity to all norms and complete learning of all assumptions, or *creative individualism*, acceptance of pivotal assumptions but rejection of peripheral ones allowing individual creativity in task creation and performance, depending upon the methods of socialization.

Now, my intention is to create a *cooperative* and *innovative* culture, so a haphazard one does not evolve over time. Cooperation requires reciprocity as its guide, yet forgiveness is common. Recalling Axelrod's advice, we must emphasize the future relative to the present and reward cooperation appropriately. By innovation, I imply the ability to recognize alternative or unique concepts for application to or change of current practices. Innovation requires diversity, breadth of knowledge, and freedom to experiment. Schein indicates, "to make people feel safe in learning, they must have a motive, a sense of

direction, and the opportunity to try out new things without fear of punishment."[83] Obviously, our objective in member socialization is creative individualism. Such objectives require careful consideration of the embedding mechanisms and socialization principles suggested by Schein.

Throughout our discussions in previous sections of the chapter, support for such a culture is implicit. At the artifactual level, the organization is structured to foster outside contact through subcontracting, thus expanding the organization's breadth of interaction and indirectly increasing its knowledge base. Further, the structure supports autonomy among organizational units. Status hierarchies are diminished through titling organizational members as either directors or coordinators, thus possibly facilitating freedom of interaction, and the information infrastructure allows interaction and access to everyone. Other possible artifactual mechanisms for consideration are a corporate or business unit reading program where appropriate literature is assigned and discussed in roundtable forums or written corporate philosophies espousing priorities or intentions.

We cannot expect these artifactual mechanisms to instill the intended culture. Embedding mechanisms such as leadership and measurement are the keys for success. Previously, we discussed the suggestions of Mort Myerson, and I can think of no better advice for enhancing an innovative and cooperative culture, yet his advice, though excellent, requires shifts in our notions of leadership. As mentioned, I cannot suggest a methodology for learning this style of leadership, nor do I think it would be appropriate for me to do so. I expect that this form of leadership will evolve over time by installing the correct measurements and attracting the right people. Our prior discussions highlight my thoughts on measurement, so I shall not again discuss them. Suffice it to say, that emphasis on long-term reward is paramount. Finally, member socialization requires individual recruitment, informal training through mentoring or apprenticeship programs, variable promotion when the member is prepared to progress, and tolerance for mistakes or failure.

I hesitate to endorse discrete steps for instilling an intended culture, but I hope to have introduced enough concepts to guide its creation. Reflecting, I remind myself of the power of "chaotic evolution" where limited but core concepts allow the parts to complete the whole, so I hope I have obliged this concept.

---

[83]Schein, E. "How Can Organizations Learn Faster? The Problem of Entering the Green Room", MIT Sloan School of Management, April, 1992, p. 21.

6.6 Summary

This chapter has introduced six qualities of a future organization inspired by the philosophies of sustainable development and decentralization: continuity, connection, trust and cooperation, competitive spirit, diversity, and congruent values. Juxtaposed against them are the realities of the current environment of remediation where industry consolidation, risk communication, increasing client demands, and technological innovation will continue to influence the industry in the coming years. These qualities and realities, in turn, guided the discussion of a future remediation organization. I attempted to create an abstract model for a national remediation organization in the 21st century by discussing its purpose, structure, management, and culture. It shall provide full remediation services through a knowledge of systems integration and coordination as a comprehensively responsible and accountable organization. Its structure is lean to encourage autonomy, ownership, and subsidiarity. Organizational leadership and management promote diversity, cooperation, and constructive dissension supported by a comprehensive measurement system that emphasizes goal formulation and long-term rewards. Finally, its culture is the bond of the organization whereforth springs a cooperative and innovative environment.

Chapter 7
CONCLUSION

The most useful piece of learning for the uses of life is to unlearn what is untrue.
- Antisthenes

7.1 Final Thoughts

Current trends in ecological and business management are dramatically influencing the form of organizations in the next century. Decentralization is a trend in business management that emphasizes flexible organization through competency discovery, development, and complementation, lateral coordination, and autonomous decision-making. Sustainable development is a direction in ecological management that emphasizes economic and ecological harmony. Within the remediation industry, trends in market situations, liability issues, and technology development all have tremendous implications for future remedial work. Our discussions have hopefully created the foresight necessary for organizations to prepare for the next century.

In chapter three, we examined how the market situation continues to evolve. In the mid-80s, a variety of firms diversified into remediation. Today, fierce competition and an oppressive regulatory system have dampened the market's promise. DOD provides the most potential for short-term revenues by providing large turnkey projects for remediation vendors, but possible public policy changes indicate a shift from cleanup to containment technologies and services as questions are raised about the economic and medical justification of extensive remediation. In chapter four, we discovered that the liability issues are handled rather well through traditional approaches to risk management, but remedial contractors are unprepared and hesitant to assume risk communication responsibilities. Research into societal risk perceptions suggests that unprecedented cooperation between government, industry, and the public is necessary to avoid stagnation. Each must lend credibility to the other for possible success. In chapter five, we examined the difficulties of technology development in an industry oppressed by regulatory uncertainty. Future regulations may make developing or developed techniques obsolete as the current incineration and cleanup policy debates indicate. Perhaps, the only recourse for the industry is to keenly monitor the situation and posture itself to adapt as necessary. An EPA-facilitated informal gatekeeper network as a method for technology transfer and information dissemination may provide these abilities. These specific trends will significantly affect potential organizational strategies.

Finally, in chapter six, we introduced six qualities of a future organization inspired by the philosophies of sustainable development and decentralization: continuity, connection, trust and cooperation, competitive spirit, diversity, and congruent values. These qualities and the insights from chapters three through five guided the discussion of a future remediation organization. I attempted to create a generic model for a national remediation organization in the 21st century by discussing its purpose, structure, management, and culture. Its strengths are its ability to coordinate multiple systems, its knowledge acquisition and development, its lean and autonomous structure, its authentic and equitable leadership and management, and its cooperative and innovative environment.

I suspect the success of this model rests upon the organization's leadership. This century has reinforced notions of coordination and production that were successful in the past but improbable for the future. How well we "unlearn" these notions will predict our success as the leaders, strategists, and designers of future organizations.

7.2 Further Research

By no means have I exhaustively considered all the issues raised here. I am sure research in the following areas would prove meaningful for the discussion of future organizations and fruitful for us all:

1. I have hinted at the uncertainty of future cleanup policy in this country all through this thesis, but my conclusions were based upon fairly cursory insights rather than pure research. More study is needed to forecast the direction of future remediation policies.
2. If the demand for containment services and technologies increases as a result of policy changes, then more research into organizational strategies and containment techniques and systems is appropriate. Even without policy shifts, such research could insight more sensible economic and medical approaches to cleanup.
3. I have suggested that the "death of the job" is possible. Perhaps, the "death of the organization", as we know it, is not far behind. More study of remote interaction and its influence upon jobs and organizations is paramount. How will "home employment" change our world? I have hinted at the idea of organizations becoming "membership clubs" for social interaction and knowledge exchange, so how will this work? Do organizations evolve into loose consortiums of people with similar interests and complementary skills? How will this affect national economics, revenue distribution or financial exchanges? Will all work occur on a per diem basis?

4. Finally, synchronous systems will unquestionably impact the coordination paradigm of the next century. What system capabilities and features are most appropriate for remediation?

REFERENCES

Interviews

Joe Celi, President, GZA Remediation, Inc.

Bruce Laswell, Group Senior Vice President, Environment & Energy Group, ICF Kaiser International, Inc.

Mike Long, Vice President, Business Development, Perland Environmental Technologies, Inc.

Ryan McKelvey, Senior Analyst, International, L.L. Bean, Inc.

Mark McKenzie, Environmental Engineer and Installation Restoration Program Coordinator, Pease Air Force Base, NH.

Bruce Miller, Senior Vice President, Chief Operating Officer, Perland Environmental Technologies, Inc.

Burt Millikan, USACE Procurement Policy Officer for TERCs

Ira Nadelman, USACE New England Division TERC Manager

Norman Nelhuebel, Director, Remedial Technologies, Clean Harbors Environmental Services.

Richard Simon, Executive Vice President, Professional Practice, GZA GeoEnvironmental Technologies, Inc.

Lectures and Seminars

John Seely Brown, Vice President and Chief Scientist; Director, Xerox PARC, Xerox Corp., Lecture delivered at MIT via video conference on September 21, 1994.

Rick Gorski and Jack Wiseman, Vice Presidents, McDermott International, Presentation at MIT, November 1994.

Dee Hock, Retired CEO, Visa International, Lecture delivered at MIT on September 28, 1994.

Mort Myerson, CEO, Perot Systems Corp., Lecture delivered at MIT on November 30, 1994.

John Sullivan, CEO and President of Perland Environmental Technologies, Inc., Speech delivered at MIT on March 4, 1994.

Center for Construction Research and Education's Consortium on the Global Environment and the Construction Industry Research Group Meeting, April 1994, where members of EPA's Region One were in attendance.

Center for Construction Research and Education's Roundtable Workshop on Risks and Opportunities in the Hazardous Waste Remediation Market at MIT on November 10, 1994 where several remediation organizations had representatives present.

Literature

Abernathy, W. and Clark, K., "Innovation: Mapping the Winds of Creative Destruction" in Tushman, M. W. and Moore, W. L., Readings in the Management of Innovation, 2nd ed., Cambridge, MA: Ballinger, 1988.

Allen, T., Managing the Flow of Technology: Technology Transfer and the Dissemination of Technological Information within the R&D organization, Cambridge, MA: MIT Press, 1977.

Anonymous, "Copper Plant's Silver Lining", ENR, August 22, 1994.

Anonymous, "Pentagon Update - Base Closures and Cleanup", The Military Engineer, July 1991.

Anonymous. "A Master Class in Radical Change", Fortune. December 13, 1993.

Anonymous. "California Eases Rules to Spur Growth of Jobs", ENR, November 22, 1993.

Anonymous. "DOE Cleanup Is Scrutinized", ENR, February 15, 1993.

Anonymous. "DOE Rethinks Strategy to Clean Up Hanford", ENR, April 19, 1993.

Anonymous. "DOE to Clean Up Its Act", ENR, June 7, 1993.

Anonymous. "Fear of Trying", Civil Engineering, April 1991.

Anonymous. "Florida Cleanups Limp Along", ENR, February 21, 1994.

Anonymous. "Fund Pushed to Speed Reuse of Toxic Sites", ENR, November 15, 1993.

Anonymous. "Responsible Care", Chemical Week, July 7-14, 1993.

Anonymous. "State Can Oversee Cleanups", ENR, April 19, 1993.

Axelrod, R. The Evolution of Cooperation, New York: BasicBooks, 1984.

Balco, J. "Managing Risk in an Engineering and Environmental Company", Risk Management, June 1993.

Banaji, D. Contracting Methods and Management Systems of Remedial Action Contracts within the US Navy's Installation Restoration Program. Thesis submitted to the Department of Civil and Environmental Engineering, MIT, Cambridge, MA: September 1993.

Batsel, K. and Harris, D. "Florida's Innovative Procurement System Speeds Cleanups", ENR, Special section on environmental engineering, April 12, 1993.

Bella, D., Mosher, C., and Calvo, S. "Establishing Trust: Nuclear Waste Disposal", Journal of Professional Issues in Engineering, 1988.

Bradford, H., Rubin, D., and Barber, J. "O' Leary Sics OSHA on DOE", ENR, May 17, 1993.

Brittan, D. "Being There: The Promise of Multimedia Communications", Technology Review, May/June 1992.

CERES. "A Healthy Economy and a Healthy Environment", 1994.

Chatman, J. "Matching People and Organization: Selection and Socialization in Public Accounting Firms", Administrative Science Quarterly, Winter 1991.

Clean Harbors Environmental Services, "Annual Report, 1993", Quincy, MA.

Colby, M. "Evolution of Environmental Management Paradigms", Ecological Economics, March 1991.

Construction Industry Institute. Allocation of Insurance-related Risks and Costs on Construction Projects, November 1993.

Coursey, D. and Bozeman, B., "Technology Transfer in U.S. Government and University Laboratories: Advantages and Disadvantages for Participating Laboratories", IEEE Transactions on Engineering Management, November 1992.

Defense Environmental Restoration Program, Annual Report to Congress for FY91. US Department of Defense, February 1991.

EBI. "Redefining the Environmental Industry", Environmental Business Journal, April 1994.

EBI. "Site Remediation Markets", Environmental Business Journal, August 1994.

EBI. "Sustainable Development", Environmental Business Journal, July 1994.

Efron, E. The Apocalyptics, New York: Simon & Schuster, 1984.

Ellis, C., Gibbs, S. and Rein, G. "Groupware: Some Issues and Experiences", Communications of the ACM, January 1991.

Ember, L. "White House Makes Heroic Effort to Get Superfund Renewed This Year", Chemical & Engineering News, May 9, 1994.

ENSR Corp. and Sidley & Austin, Superfund Handbook: A Guide to Managing Responses to Toxic Releases Under Superfund, September 1989.

ENSR Corp. and Sidley & Austin, RCRA Handbook: A Guide to Permitting, Compliance, Closure, and Corrective Action under RCRA, October 1990.

Fernald Environmental Restoration Management Team. "Fernald ERMC Typifies New Partnership between Contractors and Feds", ENR, Special section on environmental engineering, April 12, 1993.

Galbraith, J. Competing with Flexible Lateral Organizations, 2nd ed., Reading, MA: Addison-Wesley, 1994.

Garbarine, R. "In the Region: New Jersey; Making Industrial Site Cleanups Easier", The New York Times, July 11, 1993.

Goldhar, J. and Jelinek, M. "Plan for Economies of Scope", Harvard Business Review, November-December 1983.

GZA GeoEnvironmental Technologies, Inc. "Annual Report, 1993", Newton Upper Falls, MA.

GZA Remediation, Inc. "Mini-Case Study", Waltham, MA, 1992.

GZA Remediation, Inc. "Statement of Qualifications", Waltham, MA, January 1994.

Halprin, L. Freeways. New York: Reinhold Publishing, 1966.

Hamel, G. and Prahalad, C. K. "Competing for the Future", Harvard Business Review, July-August 1994.

Hammer, M. and Champy, J. Reengineering the Corporation: A Manifesto for Business Revolution, New York: Harper Business, 1993.

Handy, C. The Age of Paradox, Boston: Harvard Business School Press, 1994.

Harvard Business School, "Note on the U.S. Hazardous Waste Management Industry", Note N9-792-067, February 1992.

Hoffman, A. "Risky Business: Commercializing Remediation Technologies Fraught with Incentives, Obstacles", Hazmat World, February 1992.

Hoffman, A. The Environmental Transformation of American Industry: An Institutional Account of Organizational Evolution in the Chemical and Petroleum Industries. Doctoral Thesis submitted to the Sloan School of Management and the Department of Civil and Environmental Engineering, MIT. Cambridge: February, 1995.

Hoffman, A. The Hazardous Waste Remediation Market: Innovative Technological Development and the Market Entry of the Construction Industry. Thesis submitted to the Department of Civil and Environmental Engineering, MIT, Cambridge, MA: August 1991.

ICF Kaiser International, Inc. "Annual Report, 1994", Fairfax VA.

Ichniowski, T. "Driven to Reform", ENR, September 5, 1994.

Jain, R. K. and Triandis, H. C., Management of R&D Organizations: Managing the Unmanageable, John Wiley & Sons, New York, 1990.

Kaplan, R. and Norton, D. "The Balanced Scorecard - Measures That Drive Performance", Harvard Business Review, January-February 1992.

Katz, R. and Allen, T., "Organizational Issues in the Introduction of New Technologies", in Katz (ed.) Managing Professionals in Innovative Organizations, Cambridge, MA: Ballinger, 1988.

Keichel, W. "How We Will Work in the Year 2000", Fortune, May 17, 1993.

Kelly, K. Out of Control, Reading, MA: Addison-Wesley, 1994.

Kiechel, W. "A Manager's Career in the New Economy", Fortune, April 4, 1994.

King, H. "Pact Reached on Hanford Cleanup", ENR, October 11, 1993.

Malone, T. and Rockart, J. "Computers, Networks, and the Corporation", Scientific American, September 1991.

Moavenzadeh, F. Global Construction and the Environment: Strategies and Opportunities, New York: John Wiley & Sons, 1994.

Molnar, L. "Changes in an Environmental Law Draw Mixed Reviews from Business", The New York Times, Oct 24, 1993.

Moore, N. "Cleanup Reshaping Rocky Flats", ENR, May 16, 1994.

Moore, J., Keller, J., Ziglar, R. and Hancock, F. "Privatization Can Lower Cost of Superfund Cleanups", ENR, Special section on environmental engineering, April 12, 1993.

Morrison Knudsen Corporation, "Annual Report, 1992", Boise, Idaho.

Muhlhauser, C. and Lukacs, J. "Sustainable Development: Foundation of Future Environmental Solutions", ENR, Special section on environmental engineering, November 22, 1993.

National Research Council. Improving Risk Communication. Washington, D. C.: National Academy Press, 1989.

Nunamaker, J., Dennis, A., Valacich, J., Vogel, D. and George, J. "Electronic Meeting Systems to Support Group Work", Communications of the ACM, July 1991.

Park, D. and Wahtola, C., "Where Is the Environmental Market Headed?", ENR, Special Section on Environmental Engineering, June 6, 1994.

Parvin, J. "Army Tries TERCs to Speed Cleanups", ENR, Special Section on Environmental Engineering, November 22, 1993.

Patterson, K., Power, J. and Kiely, C. "Owners Seek Incentives for Voluntary Cleanups", ENR, Special section on environmental engineering, November 22, 1993.

Perini Corporation, "Annual Report, 1993", Framingham, MA.

Perland Environmental Technologies, Inc. "Corporate Health and Safety Policy", Framingham, MA, 1992.

Perland Environmental Technologies, Inc. "Statement of Qualifications", Framingham, MA, October, 1994.

Peters, T. Liberation Management: Necessary Disorganization for the Nanosecond Nineties, New York: Ballantine, 1992.

Powers, M. and Rubin, D., "Superfund Proves Risky for IT-and Others", ENR, April 20, 1992.

Powers, M., "Jury Rules for Cleanup Firm", ENR, May 2, 1994.

Powers, M. "DOE Sets a Course to Speed Cleanup of Its Weapon Sites", ENR, October 11, 1993.

Powers, M. and King, H. "DOE Cleanup Contracts Rattle", ENR, September 5, 1994.

Powers, M., "Jury Rules for Cleanup Firm", ENR, May 2, 1994.

Powers, M. and Rubin, D. "Cleanup Contract Protest Upheld", ENR, October 25, 1993.

Powers, M. and Rubin, D. "Cleanup Contract Protest Upheld", ENR, October 25, 1993.

Roessner, J. D. and Bean, A. S., "Industry Interaction with Federal Labs Pays Off", Research and Technology Management, September-October 1993.

Rothbar, M. and Park, B. "On the Confirmability and Disconfirmability of Trait Concepts", Journal of Personality and Social Psychology, 1986.

Rubin, D. "Leo P. Duffy: Man of the Year", ENR, February 15, 1993.

Rubin, D. "EPA's Problem-child Superfund Site Shows Signs of Improved Behavior", ENR, April 25, 1994.

Rubin, D. "EPA's Problem-child Superfund Site Shows Signs of Improved Behavior", ENR, April 25, 1994.

Rubin, D. "Leo P. Duffy, Man of the Year", ENR, February 15, 1993.

Schein, E. Organizational Culture and Leadership, 2nd ed., San Francisco: Jossey-Bass, 1992.

Schein, E. "How Can Organizations Learn Faster? The Problem of Entering the Green Room", MIT Sloan School of Management, April, 1992.

Schein, E. "Organizational Culture", American Psychologist, February 1990.

Schneider, K. "Rules Easing for Urban Toxic Cleanups", National Desk, September 20, 1993.

Schrader, S. "Informal Technology Transfer Between Firms: Cooperation through Information Trading", Working Paper #BPS-3153-90, May 1990.

Sheridan, J. "Pollution Prevention Picks Up Steam", Industry Week, February 17, 1992.

Simon, J. "A Technical View: New EPA Developments to Streamline Site Cleanups", Environmental Permitting, Winter 1992/93.

Slovic, P. "Perception of Risk", Science, April 17, 1987.

Slovic, P. "Perceived Risk, Trust, and Democracy", Risk Analysis, June 1993.

Taylor, W. "The Logic of Global Business: an Interview with ABB's Percy Barnevik", Harvard Business Review. March-April 1991.

TechKNOWLEDGEy Strategic Group. "Update on the Commercial Environmental Services Industry", September 1994.

TechKNOWLEDGEy Strategic Group. "What Happened to the Environmental Business?", December 1993.

Tunnicliffe, P., Walsh, C. and Roth, L., "Faster Cleanups: Can a CAMU Do What It's Supposed to?", ENR, Special Section on Environmental Engineering, June 14, 1993.

Tushman, M., "Managing Communication Networks in R&D Laboratories", Sloan Management Review, Winter 1979.

Yates, M., Little, C. and Williams, L. "Time to Accelerate DOE's Cleanup Program", ENR, Special section on Environmental Engineering, April 12, 1993.